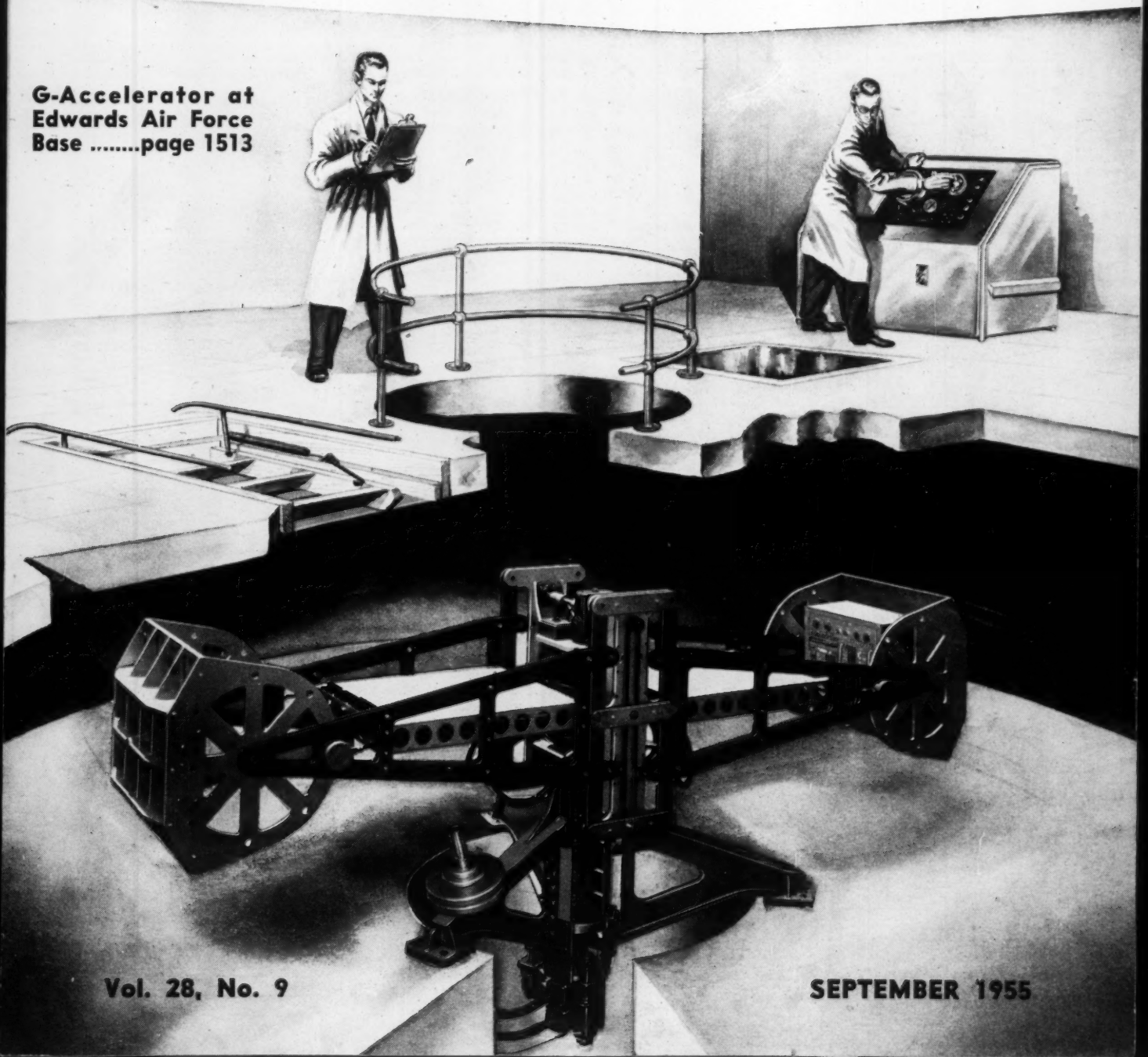
INSTRUMENTS and AUTOMATION

Including: The Journal of the SCMA *and* Simulation Council Newsletter

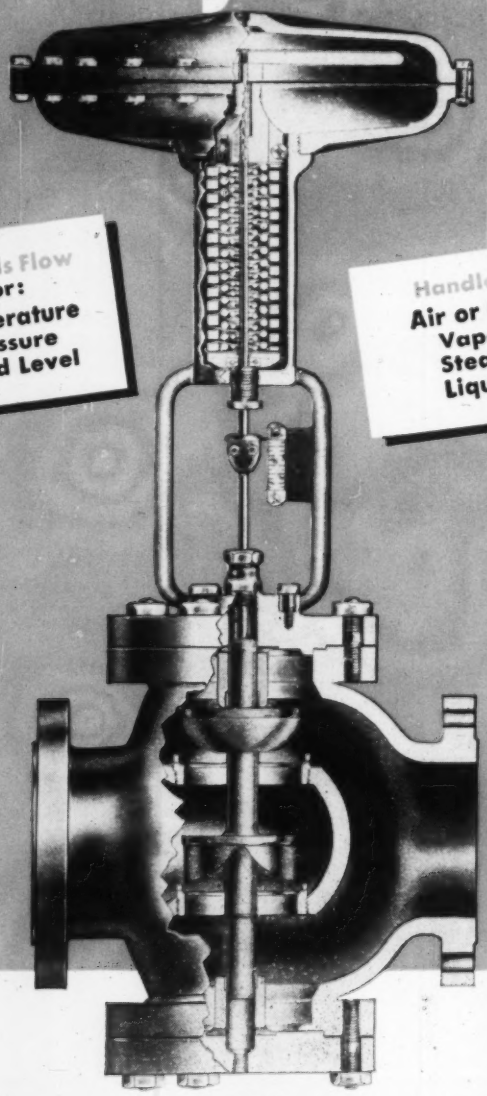


G-Accelerator at Edwards Air Force Base .....page 1513

Vol. 28, No. 9 SEPTEMBER 1955

For All Types of Systems...

BS&B Type 86 Diaphragm Control Valve Is The "Workhorse" Of The Industry!



Controls Flow For:
Temperature
Pressure
Liquid Level

Handles:
Air or Gas
Vapor
Steam
Liquid

- ✔ Wide Range of Application
- ✔ Wide Selection of Trim Characteristics
- ✔ Wide Rangeability
- ✔ Double Port—½" to 16"
- ✔ Single Port—½" to 8"
- ✔ Reversible Inner Valves

Take Both The GUESS And The WORK Out Of Controls Sizing For Liquid, Steam And Gas Applications By Using BS&B's New And Exclusive Sizing Method, As Set Forth In Our New "Controls Sizing Manual." Available On Request From Your BS&B Representative.

EFFICIENCY
OVER 60 YEARS
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RELIABILITY
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

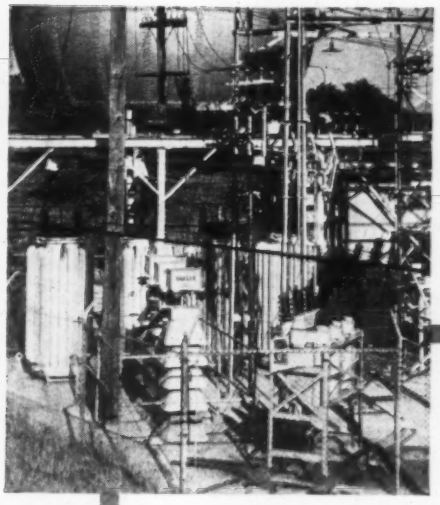
SPECIFICATIONS

Body Size: Double Port, ½" to 16". Single Port, ½" to 8"
Body Style: Screwed Globe and Flanged Globe.
Pressure Range: 125 to 5,000 lbs. within body size limits.
Temperature: Up to 800° F.
Diaphragm Pressure: 3 to 15 lbs., standard.
Material: Body—high tensile cast iron, electric cast steel, or special alloys. Trim—bronze or 18-8 stainless steel or special alloys.

If You'd Like More Information, Contact Your Nearest BS&B Representative, Or Write To...

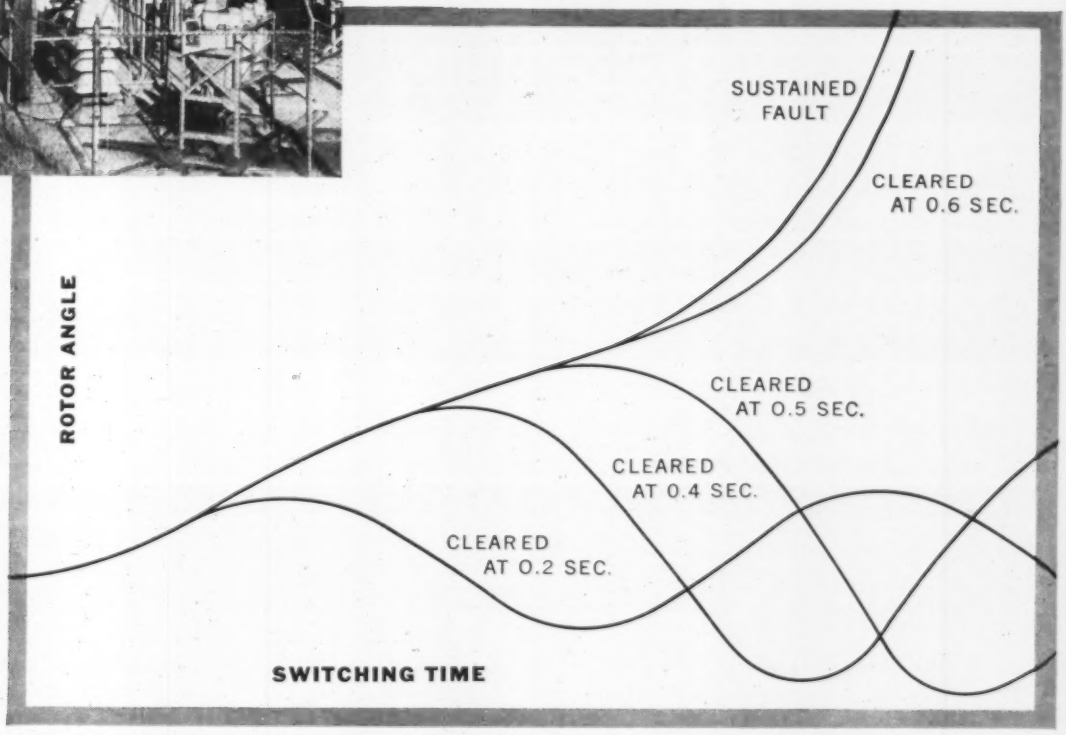
BLACK, SIVALLS & BRYSON, INC.
Controls Division, Dept. 4-V9
7500 East 12th Street
Kansas City 26, Missouri

For more information circle 1 on inquiry card.



GEDA
solves control problems

for example:



How long can a breaker take to break?

WHEN a short circuit occurs on a power system, a circuit breaker goes into operation—opening or "clearing" the fault while protecting the generator. However, the circuit breaker requires a certain amount of time to operate. If the time is too long, the generator will slow down until it gets "out of step" with the rest of the system.

The power system swing curves shown above illustrate what happens to system stability as the time lag increases. This problem of the electric power industry *and countless other problems of analysis and control in other industries*—possibly in yours—are quickly and easily solved with GEDA, the Goodyear Electronic Differential Analyzer.

The Versatile Analog Computer of Advanced Design, GEDA can deliver to you tremendous savings in engineering man-hours—eliminate empirical guesswork and costly experimentation.

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Write for full information on the complete line of GEDA Advanced Design Computing Equipment, a product of Goodyear Aircraft Corporation, Dept. 931E1, Akron 15, Ohio.

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GEDA—T. M. Goodyear Aircraft Corporation, Akron 15, Ohio

GOODYEAR AIRCRAFT

For more information circle **2** on inquiry card.

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For more information circle **3** on inquiry card.

Sensitive Research

LABORATORY STANDARDS

Model BS

D.C.
SELF CHECKING
VOLT-AMP-MILLIAMMETER
ACCURACY — .05 of 1% full scale.
20 RANGES — .1 volts to 3,000 volts and 1 M.A. to 30 amps. full scale.
Internal Standard Cell—12" Hand Drawn Mirrored Vernier Scale.

Model THACH

A.C.-D.C.
SELF CHECKING
VOLT-AMP-MILLIAMMETER
ACCURACY—.2 of 1% DC and AC to 4,000 CPS.
19 RANGES — 1 volt to 1,000 volts and 10 M.A. to 5 amps. full scale.
Internal Standard Cell — 6" Hand Drawn Mirrored Scale.

LABORATORY STANDARDS listed below have an accuracy of .1 or 1% and 12" hand drawn mirrored vernier scales.

Model DYL — 18 Ranges AC Current and Voltage from 50-500 CPS.
Model L — DC and AC from 30 V. and 50 M.A.
Model B — DC from 30 Microamps and 50 M.V.
Model LW — DC and AC from 25 Watts at 20% PF.

Inquiries Invited — Write Dept. IA 5.

SENSITIVE RESEARCH INSTRUMENT CORPORATION
NEW ROCHELLE, N. Y.

Symbol of Quality — ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1927

For more information circle **4** on inquiry card.

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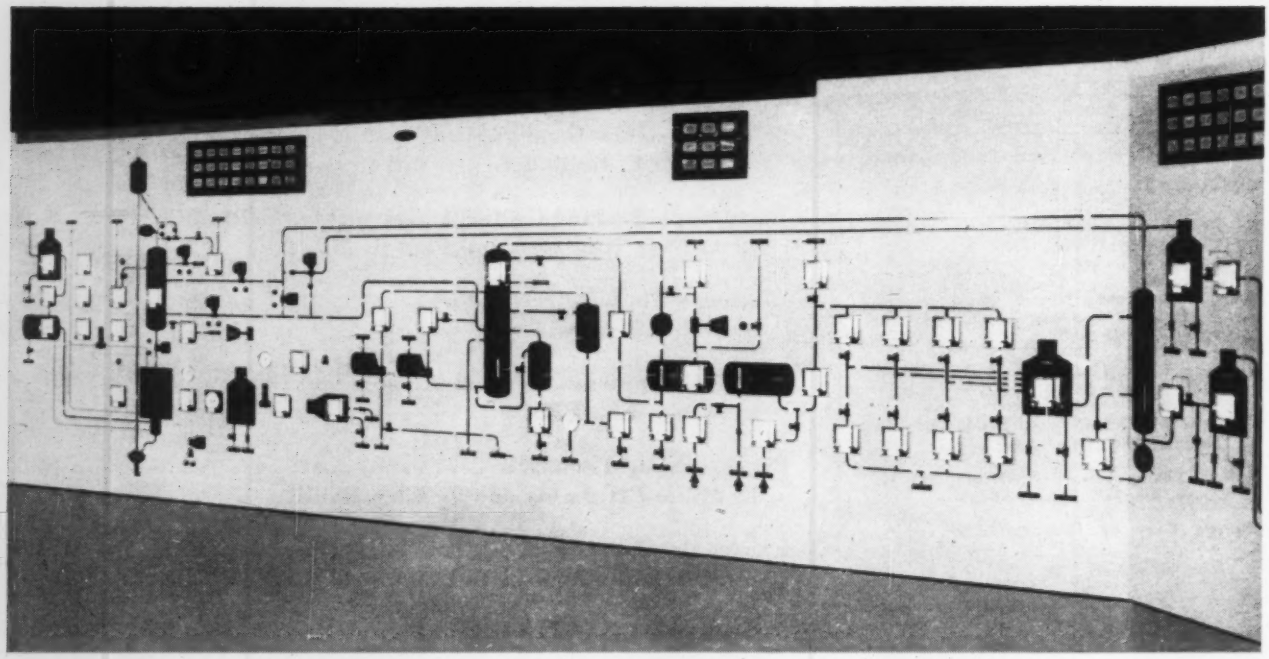
BRISTOL'S
Metagraphic Receiver line



THIS TYPICAL GRAPHIC PANEL OF BRISTOL METAGRAPHIC INSTRUMENTS IN AN OIL REFINERY FEATURES:

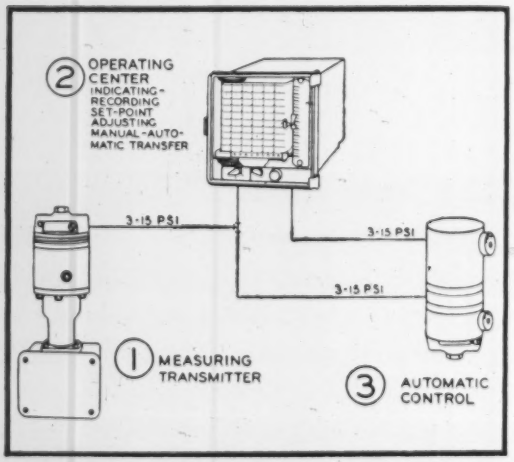
Human engineered, scientifically designed scales for error-free close-by, as well as distant, readability.

Molded clear plastic doors improve visibility to the limit – no shadows or reflections.

All measurements are on the same scale plate.

The instrument presents readings to the process operator in the most easily grasped form. High-visibility, colored fluorescent paints are used on pointers to enable operators to easily tell them apart. All pointers for a given function are the same color in all instruments.

A new degree of performance, flexibility, and ease of servicing in a pneumatic receiver



HOW THE METAGRAPHIC RECEIVER HOOKS INTO CONTROL SYSTEM. Note that Metagraphic Receiver is *outside* the control loop. As a result, unplugging the receiver creates no transient disturbance in the control loop.

FULL PLUG-IN SERVICE: The chassis of a Metagraphic receiver is built for full plug-in service. It is of one-piece construction and can be withdrawn to an intermediate position for servicing, without interrupting its operation, or completely removed from the case (no tools required).

Flexibility. Full plug-in construction provides a flexibility of use that can't be matched. A recorder can be changed to an indicator or vice versa in less than 10 seconds by merely replacing chassis. One model can be changed to another or, if trouble is suspected, the doubtful unit can be replaced by a spare.

No interruption whatever to automatic control when receiver chassis is removed. The set point and manual-automatic transfer station are part of the receiver case. With the chassis removed from the case the controller functions as a blind controller. You get the same automatic control with chassis removed.

When a recorder chassis is replaced the chart can be easily removed and put on the new chassis.

Ease of servicing. Little or no maintenance is required. Simplicity of construction and plug-in feature make it possible, if trouble is suspected, to check receivers while they are still in operation by pulling chassis out to the intermediate position

For more information circle 5 on inquiry card.

gives you 35 models to choose from

where it can be inspected, charts changed, pens inked, zero adjusted, and clocks serviced. A receiver suspected of giving trouble can be replaced in a few seconds with a stand-by unit and checked and serviced in the service shop – out of service time is thus eliminated.

Anybody can learn to check and service a Metagraphic Instrument in a few minutes.

CONTINUOUS VALVE POSITION INDICATION on same instrument scale plate as set point scale gives continuous data on control valve position – makes "bumpless" transfer possible, simply by matching pointer positions – no need to read actual scale values – minimizes reading errors – speeds operations.

IDEAL FOR GRAPHIC PANEL AND CONSOLE USE: More instruments can be mounted in a given panel area than with any other type of receiver.

They fit into a 4-9/16" square cut out – no notches required.

They mount 6-1/2" center to center on panel (6-1/2" and 7" with controller plugged into receiver case).

SCALES ARE SCIENTIFICALLY DESIGNED for instant, error-free readability – a new degree of close-up, as well as distant, readability. Control information can be obtained at a glance at distances up to 20 feet by noting whether pointers match – no need to read scales.

OFFERED FOR UP TO 3 MEASURED VARIABLES – With air pressure regulators or air-loaded regulators, three-position manual-automatic transfer valves for automatic control, and six-position (on same knob) transfer valves for cascade control.

ALL MEASURING ELEMENTS in receiver are the same high quality and accuracy. They all indicate on the same scale plate.

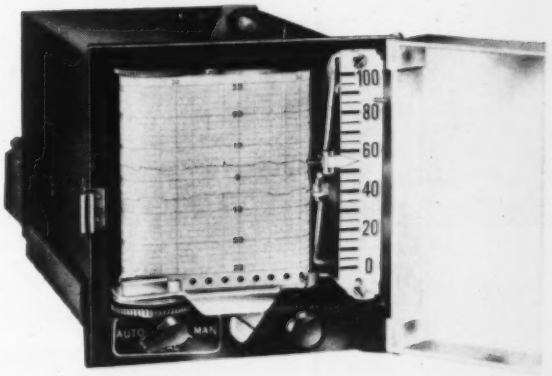
AIR CHART DRIVES are 100% pneumatic operated – no electricity is needed in control room for clock – operates off 20 psi air supply.

UNIVERSAL PIPING MANIFOLD can be adapted to any piping (2-pipe or 4-pipe system). Only a screw driver and wrench needed – no parts required.

HIGH-VISIBILITY COLORED FLUORESCENT PAINTS are used on pointers so operators can easily tell them apart. Pointers for a given function are the same color in all instruments. Control information can be obtained at a glance at distances up to 20 feet by noting whether pointers match or have deviated from each other – no need to read scales.

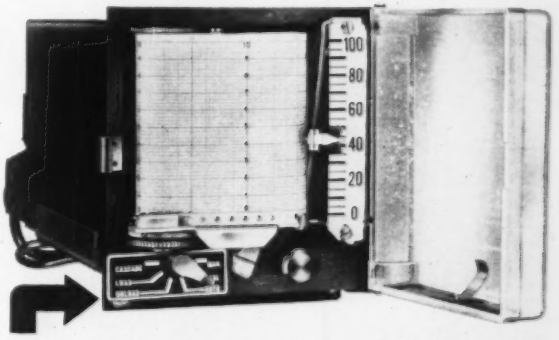
Write for the Bristol Metagraphic Receiver bulletin. The Bristol Company, 113 Bristol Road, Waterbury 20, Conn. 5 31

TWO-PEN RECORDING RECEIVER



THIS METAGRAPHIC TWO-PEN RECORDING RECEIVER, with Manual-Automatic Station records, indicates, and controls one measured variable, records one related variable on the same chart, and gives a continuous indication of either set-point or valve-position whichever is desired. If valve position is chosen to be continuously indicated, set-point may be indicated by depressing the valve knob or vice versa. The two recorded variables are at *no time* disturbed.

SIX-POSITION TRANSFER VALVE



SIX POSITION TRANSFER VALVE (on one knob) for cascade control.

Metagraphic instruments measure, record, indicate and automatically control:

Pressure	**Liquid Level**
Vacuum	**Flow**
Absolute Pressure	**Temperature and**
Differential Pressure	**Mechanical Motion**

BRISTOL

POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION

For more information circle **5** on inquiry card.

COSTS NO MORE THAN ORDINARY OSCILLOGRAPHS

Even though the new General Electric PM-20 general-purpose oscillograph has many features not found on comparable oscillographs, it is priced at only $4,200* net.

A WIDE RANGE of frequencies—from d.c. to 6,000 cps—can be recorded at speeds from 0.8 to 100 inches/sec with the new oscillograph.

AUTOMATIC RECORD NUMBERING, timing lines, trace interruption for identification, and automatic record-length control are a few of the many additional features provided for convenient operation.

*Galvanometers and magnet assembly are not included.

PM-20 OSCILLOGRAPH

4 **EASY-ACCESS DESIGN** facilitates fast operation and maintenance. Both galvanometer banks and the gear train are

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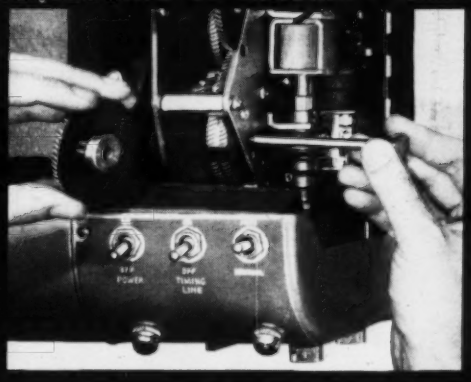
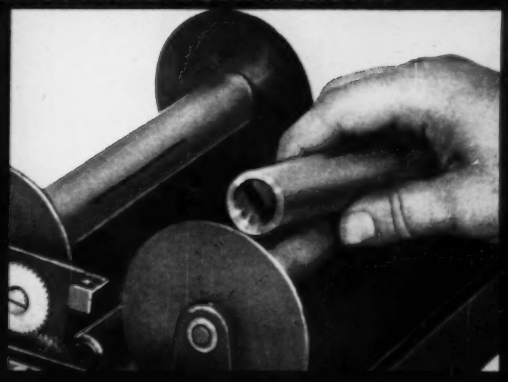
New Industrial Oscillograph with 5 Exclusive Features

FOR DYNAMIC OR STATIC TESTING OF AIRCRAFT AND INDUSTRIAL EQUIPMENT . . .



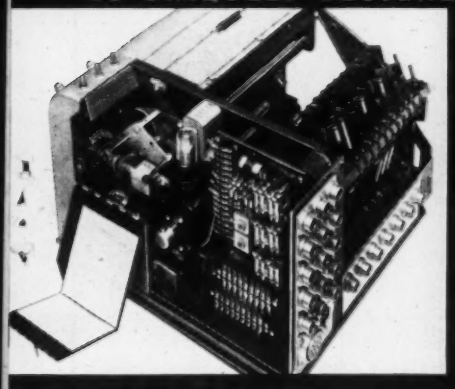


1 **71-GALVANOMETER CAPACITY** in two banks gives versatility in measuring and recording many variables simultaneously.

2 **ONLY 2 IDLER GEARS TO CHANGE** and both are always in use eliminating storage and the chance of loss. No tools are necessary to move the gears.

3 **MAGNETIC SPOOLS** in the record holder simplify loading. The spools automatically position themselves in the record holder.

IS UNIQUELY DESIGNED FOR EASY OPERATION AND MAINTENANCE



readily accessible through hinged doors in the lightweight aluminum case. The entire cover may be removed by loosening three fasteners.

5 **SEPARATE VIEWING LAMP** eliminates adjustments of recording lamp intensity for viewing. Lamps are easily accessible by removing the record holder.

FOR MORE INFORMATION, contact your nearest G-E Apparatus Sales Office or use the coupon above to request a copy of bulletin GEA-6348.

GENERAL ELECTRIC COMPANY
SECTION A585-5
SCHENECTADY, N. Y.

Please send me the following bulletin:
PM-20 General-purpose Oscillograph (GEA-6348)

Name .....

Company .....

Street .....

City ..... **Zone** ..... **State** .....

Progress Is Our Most Important Product

GENERAL ELECTRIC

For more information circle **6** on inquiry card.

TYPES AP-9 AND DP-9 have tough plastic cases and hinged covers for protection of scale and terminals. The AP-9 (a-c) has an accuracy of ¾% of full scale value; the DP-9 (d-c) an accuracy of ½ of 1%.

New Pivot-and-bearing Design Gives Longer Life to G-E Portable Instruments

Spring-mounted jewel bearings and unique pivot mounting avoid sticky pointer action for sustained instrument accuracy

GENERAL ELECTRIC'S new pivot-and-bearing design, now in all G-E portable ammeters, voltmeters and wattmeters, assures greater dependability in portable instrument performance than ever before. Unique new construction practically eliminates pivot "mushrooming" and resultant sticky pointer action; provides maximum ruggedness for longer life.

HERE'S HOW IT WORKS—Spring-mounted jewels cushion the pressure on pivot points. Beveled shoulders on the pivots ride against retainers to protect against pivot "mushrooming."

LESS MAINTENANCE is one of the big advantages of G-E portable instruments. The new pivot-and-bearing design avoids the necessity of frequent refurbishing of damaged pivots and jewel assemblies, a major maintenance problem with most portable instruments.

IN CONVENTIONAL INSTRUMENTS, tons of pressure result between pivot points and jewel bearing surfaces every time an instrument is dropped even an inch on a table top. Such shocks cause excessive pivot wear on jewel cracking. This problem is avoided in G-E portables.

FIRST INTRODUCED in G-E switchboard instruments, this new feature achieved outstanding results. Maintenance costs were cut and instruments gained longer life with sustained accuracy. Now the same results are available in G-E portable instruments for use in laboratory and production measurements.

TYPES AP-9 AND DP-9 instruments are typical G-E testing instruments incorporating the new pivot and bearing assemblies. Type AP-9 (for a-c) and DP-9 (for d-c) are used where precise measurements are required in production, maintenance, or laboratory operations.

FOR MORE INFORMATION, contact your nearest G-E Apparatus Sales Office or mail the coupon below.

PROVIDE SUSTAINED INSTRUMENT ACCURACY WITH LESS MAINTENANCE

SECTION A582-5
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Please send me a copy of the bulletin(s) checked below:

- ☐ GEC-830 Medium-size Portables
- ☐ GEC-979 Portable D-C Indicating Instruments
- ☐ GEC-377 P-3 High-accuracy Portables

Name .....

Company .....

Street .....

City ..... Zone ..... State .....

TYPES DP-11 AND DP-12 instruments are ideal for laboratory and production measurements. Both have break-resistant plastic cases and long 5½-inch scales for reading accuracy.

TYPE P-3 instruments provide sustained high accuracy of ⅛ of 1%. They are suitable for both a-c and d-c precision testing and perform well under adverse conditions caused by temperature, frequency, or external magnetic fields.

Progress Is Our Most Important Product

GENERAL ELECTRIC

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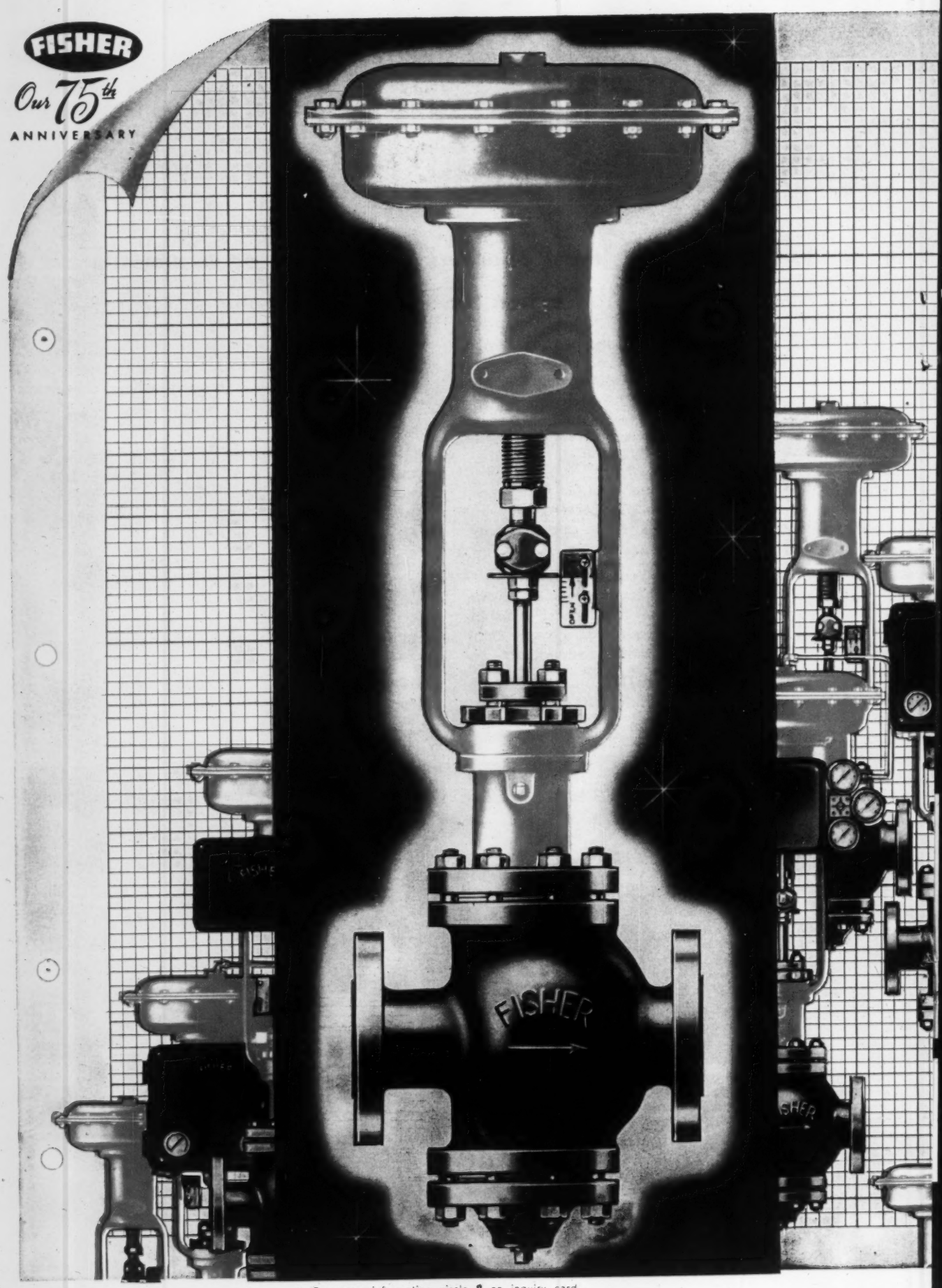

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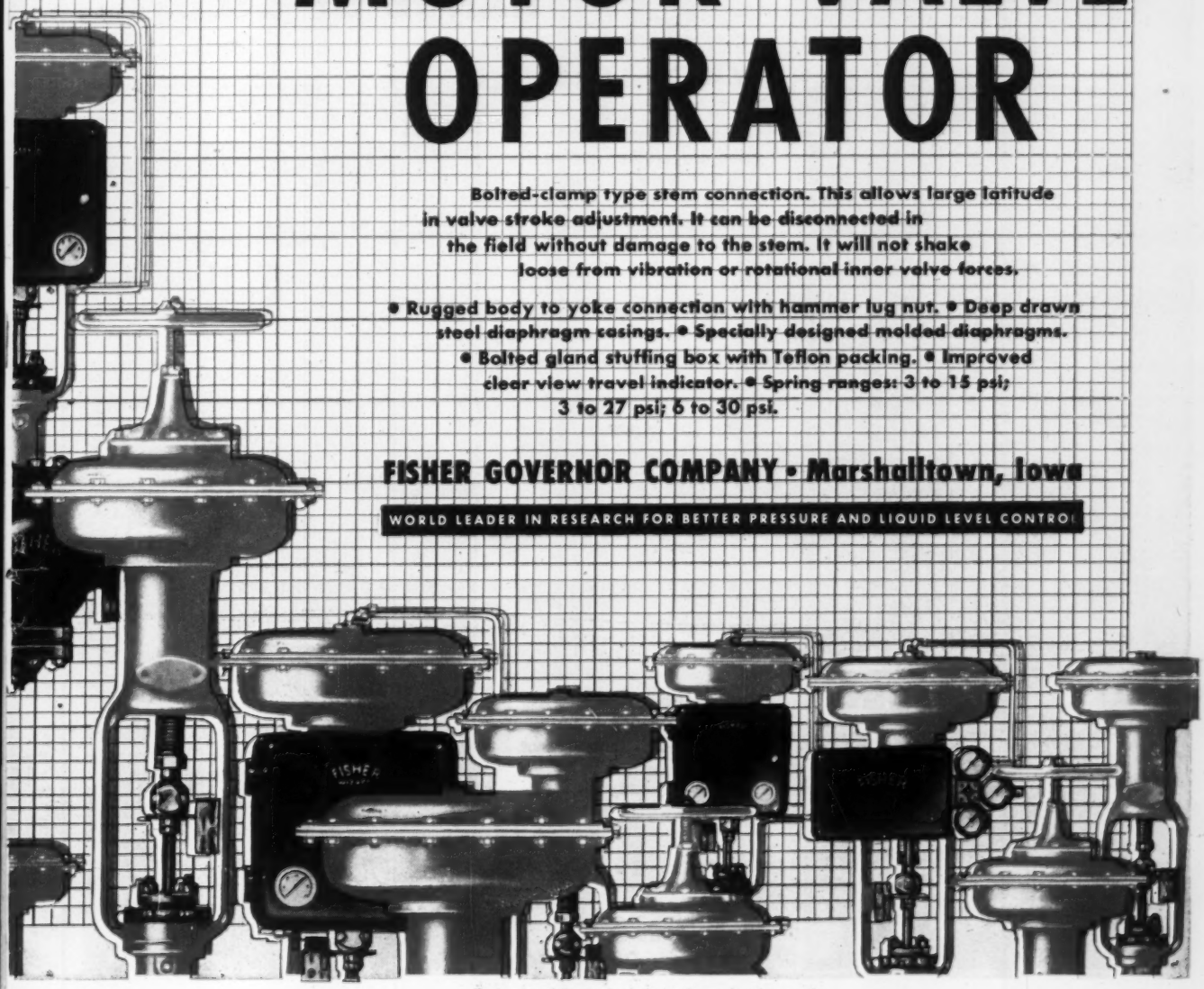
Presents An Improved

DIAPHRAGM MOTOR VALVE OPERATOR

Bolted-clamp type stem connection. This allows large latitude in valve stroke adjustment. It can be disconnected in the field without damage to the stem. It will not shake loose from vibration or rotational inner valve forces.

• Rugged body to yoke connection with hammer lug nut. • Deep drawn steel diaphragm casings. • Specially designed molded diaphragms. • Bolted gland stuffing box with Teflon packing. • Improved clear view travel indicator. • Spring ranges: 3 to 15 psi; 3 to 27 psi; 6 to 30 psi.



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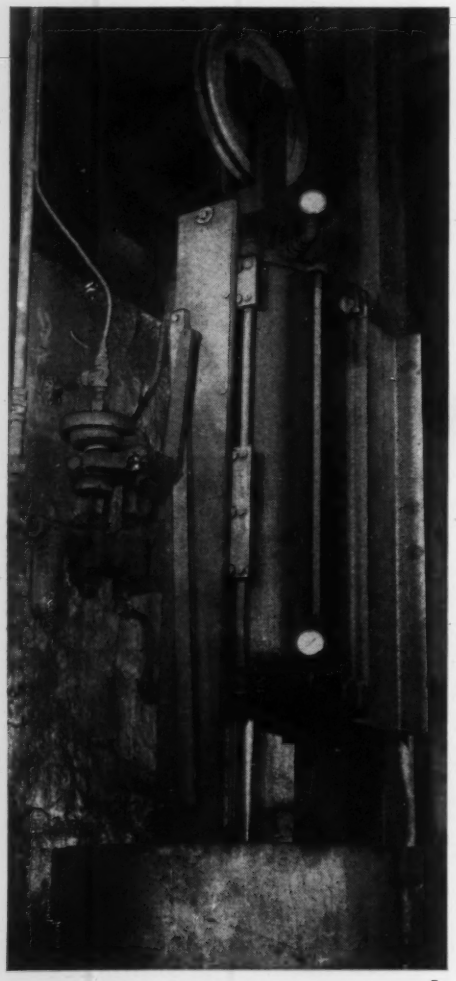
WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

For more information circle 8 on inquiry card.

MUSCLES

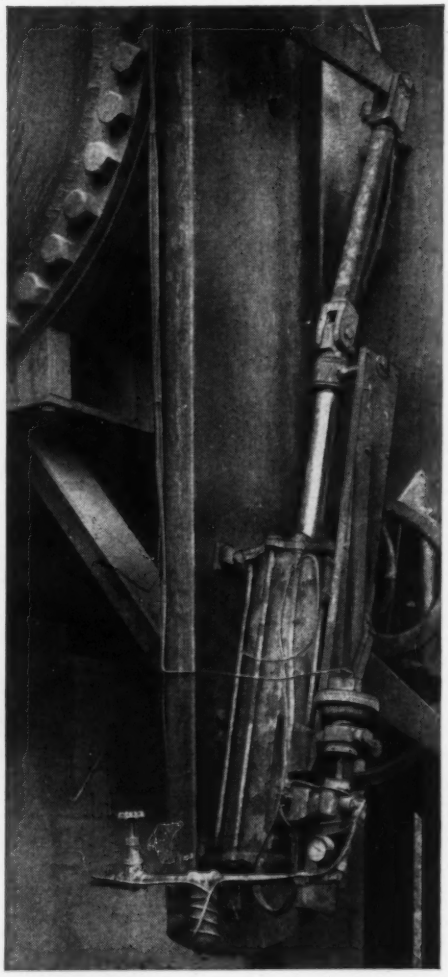
HAGAN POWER POSITIONERS IN FULL RANGE OF SIZES!

6" x 10" Hagan Power Positioners operating inlet louvers to the forced draft fans for boilers of large power plant. (midwest climate)



10" x 30" counterweighted Hagan Power Positioner for 2500 pound slide type damper.

8" x 25" Hagan Power Positioner operating 54" butterfly valve, controlling flow of blast furnace gas to boiler. (Outdoor installation, note steam tracer lines)



For more information circle 9 on inquiry card.

FOR INDUSTRY

Hagan Power Positioners are rendering dependable, accurate service under the most severe operating conditions. These rugged, double acting units assure plenty of power, and are meeting high standards of accuracy for valve, damper and lever operating applications.

Low piston leakage, low piston friction and modest cost make Hagan Precision Positioners an economical buy.

CHECK THESE MANY OUTSTANDING FEATURES:

ACCURATE—piston takes a positive position for every incoming signal. Repeatability—1%.

HIGH SPEED—90% stroke in as little as 1.0 second.

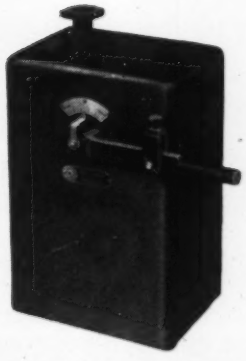
FLEXIBLE—positioning is normally linear with signal pressure, but any desired relationship may be obtained by shaping the feedback cam.

INPUT SIGNAL RANGES—complete selection of ranges—3-15, 0-30, 0-60; others available.

RUGGED CONSTRUCTION—insures dependable, long, trouble-free life.

FULL RANGE OF SIZES—4″ to 12″ bore—5″ to 48″ stroke. Full power for any need.

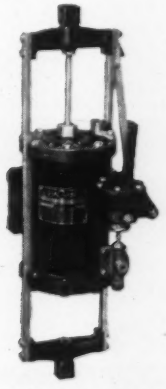
ACCESSORIES—Manual Operators—piston air locks—limit switches and many others.



4" x 5" HAGAN POWER POSITIONER

Stall torque—400 lb ft.*
90% full stroke—1 sec.
Specification Sheet TP-245

*With 100 psi power air

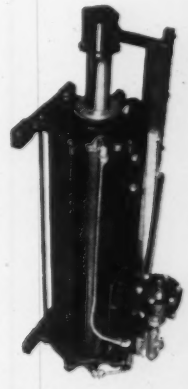


5" x 10" HAGAN POWER POSITIONER

Stall thrust—1950 lbs.*
90% full stroke—1.8 sec.
Specification Sheet TP-1510

8" x 14" HAGAN POWER POSITIONER

Stall torque—4600 lb ft.*
90% full stroke—2.5 sec.
Specification Sheet TP-2814



12" x 48" HAGAN POWER POSITIONER

Stall thrust—11,000 lbs.*
90% full stroke—6 sec.
Specification Sheet TP1100

HAGAN HALL BUROMIN CALGON

HAGAN CORPORATION

HAGAN BUILDING • PITTSBURGH 30, PENNSYLVANIA

Metallurgical Furnace Control Systems • Boiler Combustion Control Systems • Ring Balance Flow and Pressure Instruments • Control Systems for Aeronautical and Automotive Testing Facilities

For more information circle 9 on inquiry card.

ONLY the Type 13A d/p has these 6 advanced-

- **Positive Overrange Protection** up to full 1500 lb. rating
- **Fully Adjustable Ranges . . .** 0-20" to 0-80" and 0-50" to 0-250" H_2O differential
- **Automatic Internal Damping** . . . fast, *stable* measurement
- **Simplicity** . . . easiest, lowest cost installation, least maintenance
- **Convenient Zero Adjustment** . . . external — no need to remove weatherproof cover
- **Highest Sustained Accuracy** . . . even under extreme operating and ambient conditions

With these basic features, plus many other technical refinements throughout, the new Type 13A d/p Cell* Transmitter surpasses all previous records in performance . . . economy . . . convenience. For the complete story and a demonstration, call your nearest Foxboro representative. Write for new Bulletin 13-11. **The Foxboro Company, 469 Neponset Ave., Foxboro, Mass., U.S.A.** Factories in the United States, Canada and England.

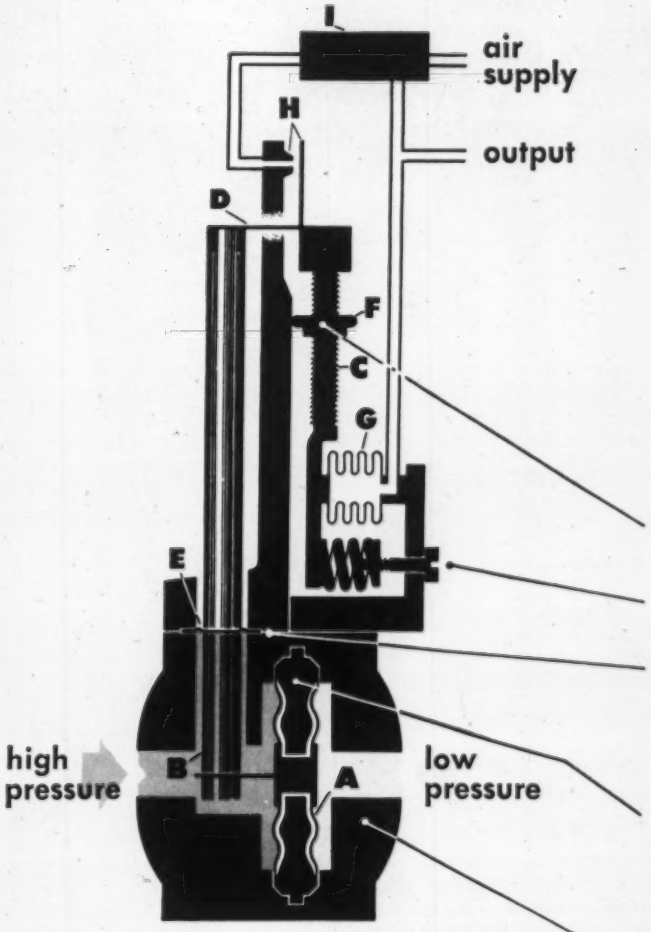
*Reg. U. S. Pat. Off.

More Foxboro flow transmitters are in use by the process industries than all other makes combined!

For more information circle **10** on inquiry card.

Cell Flow Transmitter

design features...



How It Works...

An increase in differential pressure across Twin-Diaphragm Capsule (A) exerts force to right on force bar (B). Elgiloy® diaphragm seal (E) acts as fulcrum. Force to left at top of bar (B) causes flapper to approach nozzle at (H). Resulting increase in nozzle pressure is amplified by relay (I). This pressure is sent to feedback bellows (G) which develops force to counterbalance the differential pressure on capsule (A). The 3-15 psi output signal from relay (I), always precisely proportional to differential pressure, is transmitted to remote recording or controlling instrument.

Range Wheel is continuously and easily adjustable for entire range whether 0-20" to 0-80" or 0-50" to 0-250" H_2O.

Easy-access screw adjustment permits field "zeroing" without removing weatherproof cover.

Elgiloy® stainless alloy diaphragm seal assures a corrosion-resistant, frictionless, positive pivot point. Instrument is constructed in 3 basic units — body, transmitter, and air relay block — eliminating all possibility of errors produced by piping stresses.

Silicone-filled Twin-Diaphragm Capsule filters out flow disturbances ("noise") at measurement source . . . without loss of speed of response. Precisely matched surfaces of diaphragms and capsule core provide "stops" which give positive overrange protection in both directions.

Rugged forged body, optionally Type 316 S.S. or carbon steel, gives greatest strength with least weight . . . ultra-compact design permits low cost mounting from flange taps.

FOXBORO
Reg. U.S. Pat. Off.

First in Flow Instrumentation

For more information circle **10** on inquiry card.

LEWIS PORTABLE PYROMETER POTENTIOMETERS

FOR MEASURING TEMPERATURES ELECTRICALLY

- **IN MOVING VEHICLES**
- **IN AIRCRAFT**
- **IN THE LABORATORY**

ACCURATE, DIRECT-READING, EASILY-OPERATED INSTRUMENTS, WITH ELECTRICAL COLD-JUNCTION COMPENSATION.

These potentiometers have been used for years by the leading motor car and aircraft manufacturers for proving-ground and flight-test work as well as in the laboratory.

- Three models from which to choose the instrument for your application.
  Model 13PO2, with single temperature scale.
  Model 14PO (illustrated) with high and low temperature scales.
  Model 78PO with one temperature and one millivolt scale or two temperature scales, for different thermocouple materials.
- Housed in a sturdy hardwood case, approximately 11⅜" long, 10" wide and 7⅞" high. Weight approximately 17 lbs., shipping weight 20 lbs.
- For dependable temperature instrumentation, use these potentiometers with LEWIS leads, selector switches and thermocouples.

THE LEWIS ENGINEERING CO.
NAUGATUCK, CONNECTICUT

Manufacturers of Complete Temperature Measuring Systems for Aircraft

For more information circle **11** on inquiry card.

Trends...

INSTRUMENTS and AUTOMATION

Instrumentation in railroading is expanding rapidly, including telecommunication, signalling, automatic train control, and automatic crossing devices using radio and sound detection. In marshalling yards, cars are handled automatically with electronic instrumentation, including ITV, radar speed measurement, interlocked switching, etc.

Automation in the home means greater electric power consumption. Trend: GE announces new 20-circuit split-bus circuit-breaker load center with 100-ampere main lugs, for home use.

Transistors, invented 7 years ago amid wild claims about displacing electron tubes, are finding expanding number of standard uses - - are now being made at a rate of 1.5 million per year, with forecasts for 6 million in 1956. Number of manufacturers has increased from 10 in 1953 (making 40 types), to 20 in 1954 (making 140 types), to 25 in 1955 (220 types). Fifteen types of power transistors (output 1 watt or more) are available from 6 makers. Sales of electron tubes have not been affected significantly - - electron-tube production (more than 380 million in 1954) is also increasing.

Productivity, or output per manhour labor, (based on a prewar index of 100) increased in USA from 120 in 1949 to 140 in 1954, according to British Treasury Bulletin. Productivity in England was 115 in 1949, and 125 in 1954. French productivity in 1954 is reported as 103, West Germany as 109.

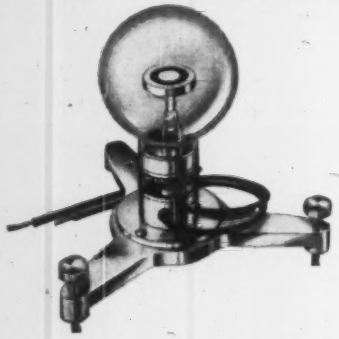
Meteorological instrumentation will benefit from closer international cooperation (weather maps are being sent via facsimile from Russia to England) and increased national emphasis. Radiosonde instrumentation is expanding because much instrumentation is involved in measuring the required pressures, temperatures, humidities, and altitudes to 60,000 ft and more. Radio, facsimile and radar applications also are increasing; new radarsonde system is undergoing field trials. Studies also on electrical characteristics of stratosphere are underway.

Medical instrumentation and electronics has received much impetus from large number of papers on the subject presented at various technical conferences. However, serious handicap has been language barrier between fields of medicine and engineering. New Center of Medical Electronics at the Rockefeller Institute for Medical Research should help eliminate this barrier and accelerate development. Many problems await solution, including use of computers in diagnosis, tumor location, electronic evaluation of glandular function, analytical problems etc.

EPLAB

PYRHELIOMETER

For the Measurement of SOLAR RADIATION



Eppley Pyrheliometers are used for solar radiation measurements at ninety-eight weather stations in the continental United States, Canada, Alaska, Greenland, Iceland, Caribbean Sea, and the Pacific Ocean. Sixty-two of these stations are under the direction of the United States Weather Bureau.

The Eppley Pyrheliometer was adopted as standard equipment by the Weather Bureau after considerable experimentation. It was found to be the best instrument so far tested by the Bureau.

Used in conjunction with a suitable recorder, the Eppley Pyrheliometer will provide an accurate and reliable record of total solar and sky radiation on a horizontal surface.

Bulletin No. 2 on Request

THE EPPLEY LABORATORY, INC.

Scientific Instruments

2 Sheffield Ave.

Newport, Rhode Island U.S.A.

Stock Report . . . .

INSTRUMENTS and AUTOMATION

The following prices and price ranges are supplied by Bache & Co., 36 Wall Street, New York 5, New York

New York Stock Exchange:

Security	Price Range for Year Thru July 29 High	Low	As of July 29, Last
American C. & C.	41 1/2	35 1/2	40 7/8
American Mach. & F.	35 7/8	25	29
American Mach. & M.	41 3/8	27 1/2	37
American Optical	53 1/4	39 1/8	48 7/8
Bell & Howell	42 1/4	30 1/2	39 1/4 - 40 (1)
Bendix Aviation	59 1/2	48	49 1/8
Bulova Watch	75 3/4	50 3/4	71
Burroughs	34 1/4	22 7/8	31 3/8
Clevite	25 3/8	20 3/4	22 1/8
Dobeckmun	38 7/8	30 1/4	37 1/4
Gamewell	39	31 1/2	32 1/4 - 32 1/2(1)
General Inst.	13	9 1/2	9 3/4
General Prec.	71 1/2	44 5/8	47
General Time	39 3/4	33 1/2	34
Hamilton Watch	25 1/4	20	20 1/2 - 21(1)
Int. Bus. Mach.	450	349	420 - 423 (1)
Minneapolis-Hon.	70	53	56 1/2
National Cash Reg.	47	37	40 3/4
Radio Corp.	55 3/8	36 3/4	49 1/4
Raytheon	25 3/4	18	20 3/4
Robertshaw-F.	33 5/8	28	30
Sangamo Electric	30 3/8	26	27 1/4
Sperry Rand	29 5/8	22 3/8	26 3/4
Square D	52	43 1/2	45 1/4
L. S. Starrett	50	40 3/4	43 1/2
Sylvania Elec.	49 7/8	41	46 3/4
Telautograph	37 1/2	25 1/2	31 3/4
Texas Inst.	16 7/8	12 1/4	12 1/2
Underwood	43 1/8	33	39 7/8

American Stock Exchange:

Security	Price Range for 1955 High	Low	As of July 29 Last
Aeroquip Corp.	17 1/2	8 1/2	13 1/2 - 13 3/4 (1)
Air Assoc.	12 3/4	8 3/4	9
American Meter	40	32 5/8	39
Beckman Inst.	26 7/8	19 3/8	22 1/2
Benrus Watch	10 7/8	9 5/8	10
Breeze Corp.	9 3/8	5 3/4	7 5/8
Consolidated Eng.	31 1/4	23 3/4	24 1/8
Dufont Labs.	17 1/8	13 1/4	14 1/2
ElectroData	17 7/8	12	13 1/8
Fairchild C. & I.	37 1/4	23 7/8	26 1/4
Int'l Resistance	12 3/8	5	10 3/4
Lear Inc.	13 3/8	8 3/4	8 3/4
Nat'l Res. Corp.	33 1/4	22 1/4	24
Neptune Meter	28 1/8	21	26 3/4
New Haven Clock	4 1/8	2 1/2	3 - 3 1/8 (1)
Norden-Ketay	19 1/2	13 1/4	13 3/4
Pneumatic Scale	31	27 1/2	30 1/2 - 31 3/4 (1)
Servmechanisms	13 3/8	8 1/4	10 1/8
Wallace & Tiernan	26 7/8	21 3/4	22 1/4
Waltham Watch	2 7/8	1 3/8	2 1/4

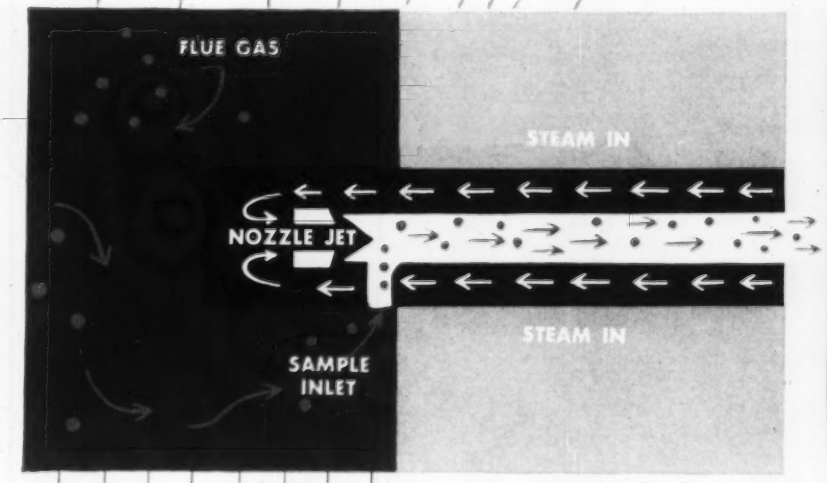
(1) Bid - Ask price, no sale.

Take stock of your future . . .

see ads on pages

1415, 1421, 1424 and 1500

NEW DIMENSIONS



in Gas Sampling

NEW SAMPLING SYSTEM OPERATES ON STEAM!

The new Hays Gaspirator* System is designed especially for difficult gas sampling problems involving high dust loading and high temperatures. It now permits accurate O_2 measurement, previously impossible in many applications.

This gas sampling system uses steam to obtain a continuous, clean sample. Suction which is created by the jet nozzle draws the sample in, where it is mixed with the steam. The steam is then condensed. Condensate and entrained solids drop down, and the sample is forced through the analyzer under pressure.

Hays, in the field of gas analysis for more than fifty years, developed the Gaspirator for use with their Magno-Therm Analyzer.

This analyzer, which operates on the paramagnetic principle, has for years been accepted as the leader in the field of O_2 measurement. Hundreds of companies are using the Magno-Therm and Hays electronic recorders very successfully in boiler plants and on process furnaces as a combustion guide, in regeneration of catalysts in refineries and in many other process applications.

For further details write for Bulletin 55-829-56.

*Patents pending.

THE hays CORPORATION
MICHIGAN CITY 8, INDIANA

For more information circle **13** on inquiry card.

Operation of Plant-Scale Installations* DEMONSTRATES BENEFITS OF ELECTRONIC PROCESS CONTROL

'American-Microsen' Electronic Process Control Installations Now In Successful Operation Have Proved The Reliability, Speed, Sensitivity And Accuracy Of This Modern Concept Of Process Instrumentation.

This is the electronic process control system that now makes it practicable to utilize the capabilities of process equipment far more fully than ever before. Revealed in actual operation of plant-scale installations are the much discussed benefits of this new approach to plant instrumentation.

Used to *measure, indicate, record and control process variables* (pressure, differential pressure, temperature, liquid level, flow, pH, gas analysis, etc.), these installations exhibit every essential to improve product quality, increase operational efficiency and plant productivity.

Only the 'American-Microsen' System provides:

Lag-free signal transmission using the simplest communication lines.

Extremely fast, accurate measurements and control responses — sensitivity impossible to duplicate in other types.

Installation of all controllers in the instrument room *any distance from the process* — even 30 miles or more.

High stability that permits use of narrower proportional bands.

Freedom from dirt, leakage, freeze-ups and other transmission line problems.

Standardized control components interchangeable at the panel and plug-in components on each instrument.

Adaptability — more than one input circuit can be fed into a controller for cascading or programming.

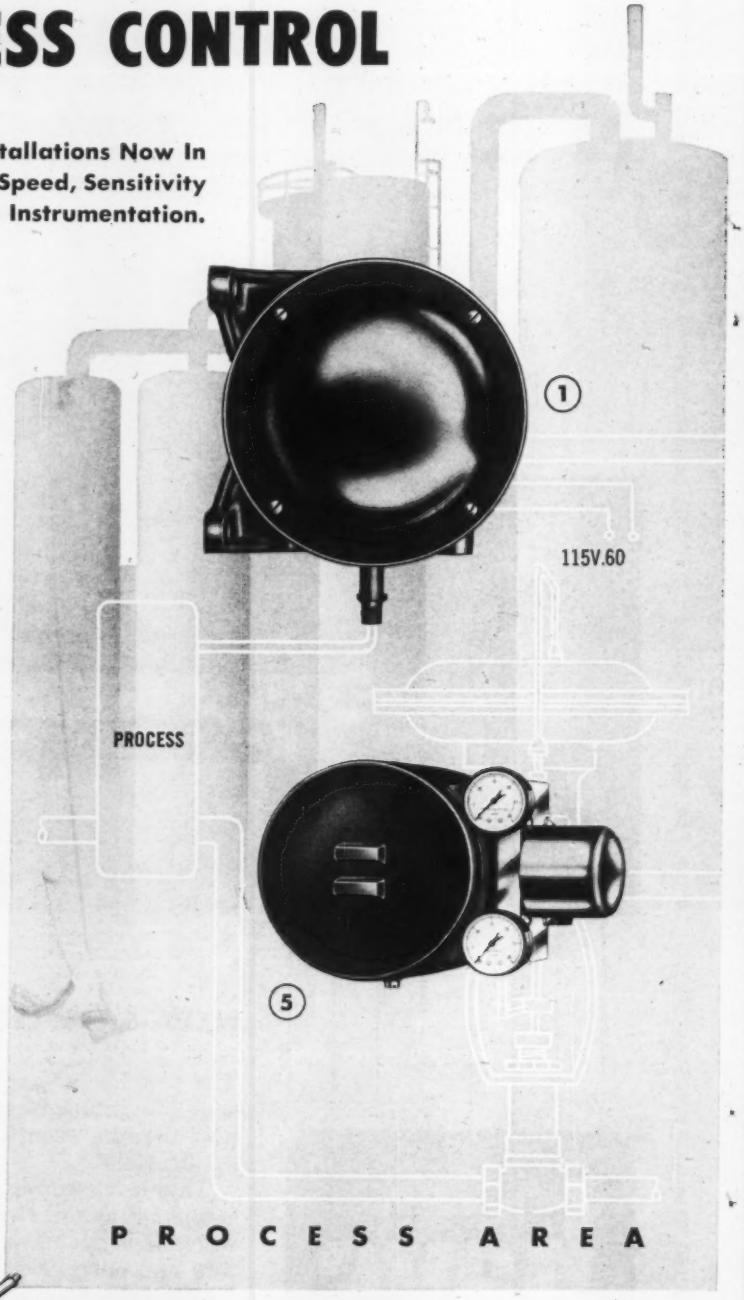
DC signal that can be fed to potentiometer recorders, digital read-out systems, monitors, computers, etc., so that process and operational data are automatically reduced to quickly usable form.

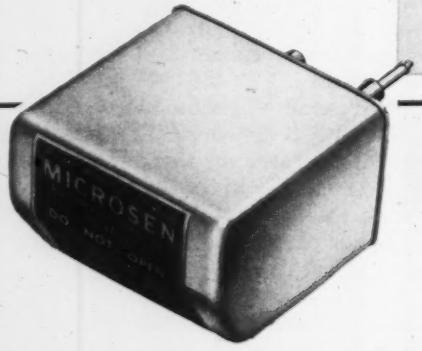
Flexibility — output signal can be fed in series to any number of receivers, without impairing accuracy. Components can be mounted anywhere convenient to operating and servicing.

Electrical circuitry makes possible unusual control and measurement functions not available in mechanical systems.

Minimum installation or maintenance investment in transmission lines, air compressors, filters, pressure regulators, dryers.

**Names and locations of installations available upon request.*





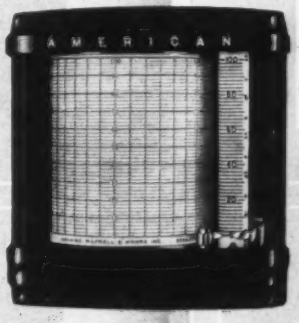
THE 'MICROSEN' BALANCE, the "nerve center" of 'American-Microsen' Instruments, is a simple, electro-mechanical servo-mechanism. It operates on the force-balance principle to produce a high-level direct current signal that is not affected by any normal electrical or ambient condition.

MANNING,

For more information circle **14** on inquiry card.

1. **TRANSMITTER.** Types to transmit measurements of temperature, pressure, differential pressure, liquid level, flow, pH, oxygen concentration, gas analysis, etc.
2. **RECORDING SET STATION.** Records on strip chart or card and compares the measured variable with the control point setting. Error signal is transmitted to the Controller.
3. **CONTROLLER.** An electronic amplifier with simple feedback circuits to produce calibrated proportional, reset and rate control actions. (Rate action added by plug-in unit.) Resulting control signal is fed to the Manual Control Station.
4. **MANUAL CONTROL STATION.** Permits switching from automatic to manual valve operation during start-up or emergency conditions. Bumpless transfer from manual back to automatic operation is built into the instrument. Retransmits control signal to Electro-Pneumatic Valve Positioner.
5. **ELECTRO-PNEUMATIC VALVE POSITIONER.** Mountable on all standard pneumatically-powered valves. Transduces the signal to pneumatic pressure up to 25 psi to operate the valve with position feedback.

Other components are available to meet your specific installation requirements.



0.5-5.0 MA.
Direct Current

115V.60

TWO-WIRE TRANSMISSION 3000 OHMS MAX.

115V.60

0.5-5.0 MA.
Direct Current

115V.60

Step up quality of control and reduce the size and cost of your process equipment for a given throughput. Shorten check-out and start-up time. Avoid costly maintenance. For your new process control system, learn about 'American-Microsen' . . . its economic advantages today and in the automatic plant of tomorrow. Catalog 164 will give you the story.

C O N T R O L A R E A

MAXWELL & MOORE
INCORPORATED

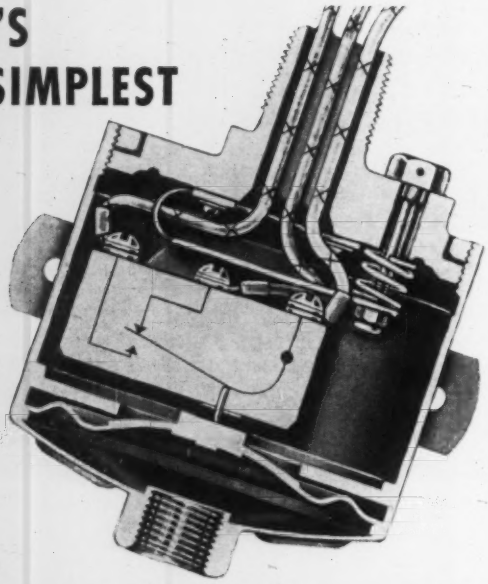
INDUSTRIAL CONTROLS DIVISION

Stratford, Connecticut

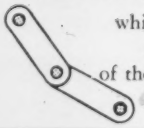
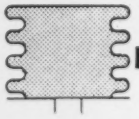
MAKERS OF 'AMERICAN-MICROSEN' ELECTRONIC TRANSMITTERS, INDICATING OR RECORDING SET STATIONS, CONTROLLERS, MANUAL CONTROL STATIONS AND ELECTRO-PNEUMATIC VALVE POSITIONERS.

For more information circle **14** on inquiry card.

HERE'S
THE SIMPLEST



DIAPHRAGM PRESSURE SWITCH

WE BUILD IN	WE DON'T USE
EXTREME ACCURACY This switch is guaranteed to repeat within + or — 1% of its original setting during its operating life.	**LINKAGES & BEARINGS**  which, as they wear, make the setting of the pressure switch drift.
OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch that uses liquid switching elements.	**LIQUID SWITCHING ELEMENTS** which make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	**ACCORDION DIAPHRAGMS**  which make the pressure switch sensitive to vibration.

BARKSDALE VALVES

PRESSURE SWITCH DIVISION

5125 Alcoa Avenue, Los Angeles 58, California

Send operating data and specifications bulletins 420-27

NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

For more information circle **15** on inquiry card.

Books...

INSTRUMENTS and AUTOMATION

Fundamental Formulas of Physics, edited by Donald H. Menzel. 1955. Prentice-Hall, New York 11, N. Y. 765 p. $10.65. 8¾ in. The work of specialists who, working independently, have produced some overlapping. Beginning with basic mathematical formulas, the volume includes material in various sciences upon which physics touches.

Automatic Plant Symposium. 1954. Philadelphia Section, Instrument Society of America, 1319 Allegheny Ave., Pittsburgh 33, Pa. An unpaged collection of papers reproduced from typewritten copy.

Magnetic Amplifiers, by H. F. Storm. 1955. John Wiley & Sons, New York 16, N. Y. 545 p. $13.50. 9¼ in. Intended for electrical engineers and senior students. The purpose is to explain the fundamentals of operation, and discuss the principal uses of magnetic amplifiers. Concerned mostly with single-phase amplifiers.

Product Flow Charts of the United States Chemical Industry, from the Chemical Economics Handbook. 1954. Stanford Research Institute, Stanford, Calif. No paging, unbound. $5. 11 in. Loose-leaf collection of sheets of various sizes.

Superfluids, by Fritz London. v. 2: **Macroscopic Theory of Superfluid Helium.** 1954. John Wiley & Sons, New York 16, N. Y. 217 p. $8. 9¼ in. An interpretation of the more important properties of superfluid helium, also called "liquid helium II".

Textbook of Servomechanisms, by John C. West. [1953.] English Universities Press, Warwick Square, London. 238 p. $5. 8¾ in. Assumes elementary knowledge of electronics and requires an acquaintance with mathematics about that of a first-year course in British universities.

Analyzing and Tracing TV Circuits, by Milton S. Kiver. 1954. Howard W. Sams & Co., Indianapolis 5, Ind. 131 p. + 6 folding plates, unbound. $3.75. 11 in. Purpose is to aid the service technician in general procedure and with specific troubles and remedies.

Magnetic Control of Industrial Motors, by G. W. Heumann, 2nd Ed., J. Wiley, N. Y. 16, N. Y., 1954, 714 p. $9.50, one of a series written by General Electric authors. Twenty chapters, essentially nonmathematical, cover principles of motor performance, controller and circuit design, and controller applications.

Electricity and Magnetism, by R. P. Wich, Prentice-Hall, N. Y. 11, N. Y., 1955, 755 pages, $7.75, 19 chapters, college level, comprise basic text on electricity and magnetism.

CEC
DataTape

Built for flight-test automation

You can't take heavy automatic data-processing equipment aloft. And yet automation of flight-test data reduction is desperately needed by today's aircraft designers, faced by mountains of raw data after just a single test flight.

CEC's DataTape offers an ideal solution to this dilemma. Compact, rugged DataTape airborne units record vast quantities of flight-performance data on multichannel tape. After the test flight, stationary ground playback equipment faithfully reproduces the electrical signals originally produced by the airborne transducers. These accurately simulated flight-test signals may then be automatically processed by high-speed digitizing and computing systems, such as CEC's MilliSADIC and ElectroData's digital computer —a completely compatible team for solving the bottleneck of flight-test data reduction. *Write today for Bulletin CEC 1561-X7.*

Here are two of the *airborne* units of the DataTape group, which also includes signal modulators, range-time generators, automatic calibrators, and complete ground playback equipment . . . *all designed specifically for the flight-test engineer.*

RECORDER

Data Channels . . . 12 or 24 standard, plus 1 flutter-control track and 1 time or voice track per 12 data channels.

Tape Speeds . . . 10, 20 and 40 in/sec; or 7½, 15 and 30 in/sec.

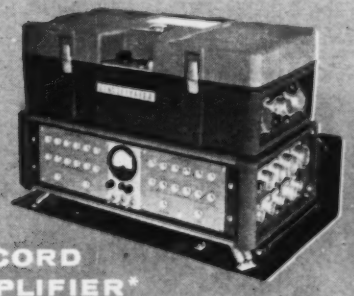
Recording Time . . . 43 minutes at 10 in/sec; 57 minutes at 7½ in/sec.

Flutter . . . less than 0.2% peak to peak (0.08% rms) over 5 to 300 cps band @ 10 in/sec. Mechanical flutter compensation on playback reduces this figure to 0.1% peak to peak (0.04% rms) in 0 to 20 cps range; electronic system compensates for flutter at higher frequencies.

Power . . . 115 volts, single-phase, 50/60/400 cps; 275 watts.

Size . . . 7 x 22 x 11¾"; 60 pounds.

Controls, indicators . . . all on top plate. Warning lamps indicate data loss from mechanical or electronic failure.



RECORD AMPLIFIER*

Channels . . . 14 or 28, including flutter-control, range-time and voice-recording tracks.

Frequency response . . . without modulators, flat ±1.6 db 300 to 18,000 cps @ 10 in/sec and 300 to 36,000 cps @ 20 in/sec; flat ±2.3 db 300 to 60,000 cps @ 40 in/sec.

Signal Input . . . 0.50 volts full scale; channel input impedance to attenuator 100,000 ohms.

Power . . . 115 volts, single-phase, 50/60/400 cps; 225 watts.

Size . . . 5⅞ x 22 x 11¾"; 35 pounds.

*Unit contains own data-channel amplifiers, power supply, bias and flutter-control oscillators, and microphone amplifier.

Consolidated Engineering *Corporation*

Electronic Instruments for Measurement and Control

300 North Sierra Madre Villa, Pasadena 15, California

Sales and Service Offices Located in: Albuquerque, Atlanta, Boston, Buffalo, Chicago, Dallas, Detroit, New York, Pasadena, Philadelphia, San Francisco, Seattle, Washington, D. C.

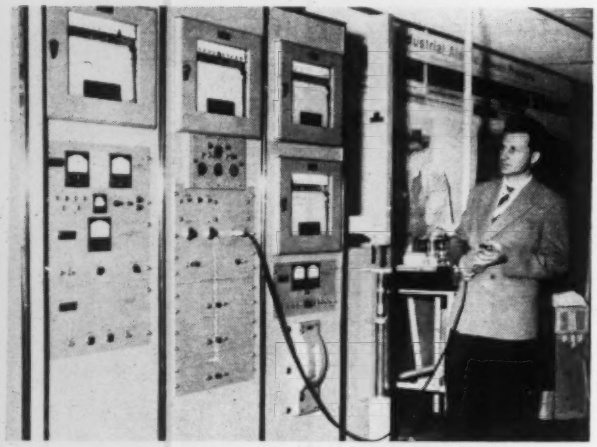
For more information circle 16 on inquiry card.

News...

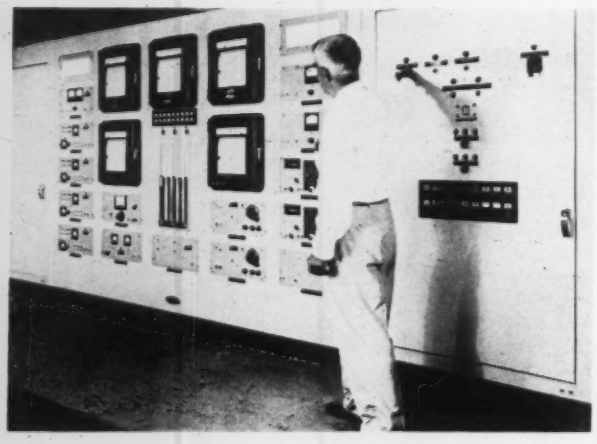
INSTRUMENTS and AUTOMATION

Atoms For Peace

GENEVA—Visitor Jean Ritzenthaler, to the Palais des Nations, Geneva, scene of the historic 72-nation "Atoms-for-Peace" conference, starts up a reactor and watches electronic units monitor the simulated explosive release



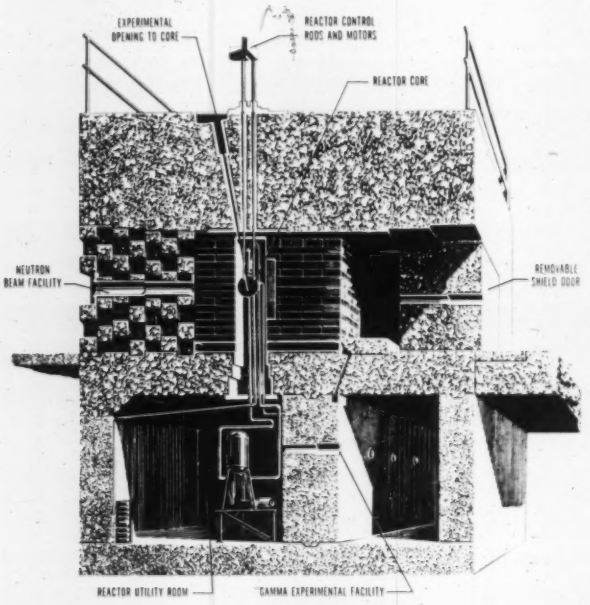
of atomic energy. The exhibit, designed by Minneapolis-Honeywell and featured in the official U. S. technical display, demonstrates how various electronic instruments can be harnessed to measure and control key aspects of a reactor's operation. There are 83 firms and organizations participating in the U.S.-sponsored exhibit, including Panellit, Daystrom, Leeds & Northrup, and other instrument companies.



Leeds & Northrup designed the operating level control channel (see Fig. 2) and provided the recording instruments which guide the crew in bringing the reactor to operating power level. The control panel for "Project Aquarium," shown in Fig. 2, was built by Panellit, who designed the unique graphic indicator (shown in the center of the panel) which depicts rod positions within the reactor.

Private Research Reactor

CHICAGO, ILL.—A nuclear research reactor designed for private industrial research will be built for the Armour Research Foundation by North American Aviation, Inc.



It is proposed to locate the reactor at Armour's operations on the campus of the Illinois Institute of Technology, Chicago. The reactor and associated equipment is expected to cost about $500,000, and is designed for 50,000 watts. It will be moderated and cooled with water, shielded by concrete, and controlled with boron steel rods. Reactor fuel is a water solution of uranyl sulfate—approximately 1 kg of U-235. That is, the reactor is of the aqueous homogeneous, or "water boiler," type.

Velocity of Light

WASHINGTON, D. C.—Two new determinations of the velocity of light have been made by National Bureau of Standards scientists. Although carried out independently by widely different methods, the two determinations give precise values that are in close agreement. They also provide confirmation for the higher values of electromagnetic wave velocity that have been consistently obtained by microwave measurements since World War II.

In one method, the velocity of light was determined from measurement of the molecular constants of carbon monoxide by infrared spectroscopy (Fig. 1). This work was carried out in the Bureau's Washington Laboratories by E. K. Plyler, L. R. Baline, and W. S. Connor of the NBS staff. The other determination made use of phase-shift measurements on very-high-frequency radio waves to obtain their velocity of propagation. These measurements were made with a radio interferometer by E. F. Florman,

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Output range (VDC)	0-325	0-500	0-500	0-600	200-1000
Output current (Ma)	0-125	0-200	0-300	0-500	0-500
Regulation accuracy	±0.5%	±0.5%	±0.5%	±0.25%	±0.5%
Ripple (MV-RMS)	5 max.	5 max.	5 max.	3 max.	20 max.
Bias supply (VDC at 0-5Ma)	0-150	0-150	0-150	0-150	—
Internal impedance (max.)	2 ohms	2 ohms	2 ohms	2 ohms	2 ohms
AC voltage (C.T., unreg.)	6.3 at 10 amp.	6.3 at 10 amp.	6.3 at 10 amp.	6.3 at 15 amp.	—
Max. bias circuit impedance	25000 ohms	25000 ohms	25000 ohms	50000 ohms	

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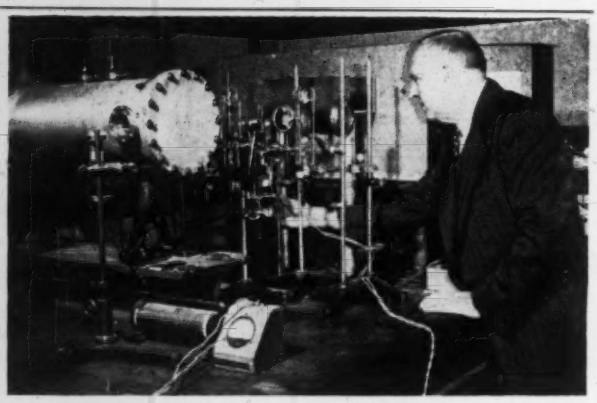


of the NBS Boulder (Colo.) Laboratories, on a dry lake bed in southeastern Arizona.

The velocity of electromagnetic waves has been a subject of investigation for many years. In the period preceding World War II, the value 299,776 ± 4 kilometers per second was generally accepted as an average of the findings of the various laboratories. However, since the war, higher values have been obtained by most investigators, largely through measurement of the velocity of propagation of microwaves. Consideration of recent work has led to an average value of 299,793 ± 1 km/sec. The results obtained by the Bureau give 299,792 ± 6 km/sec by the molecular constants method and 299,795.1 ± 3.1 km/sec by the radio interferometer. They thus provide independent confirmation of the higher values obtained in other laboratories since World War II.

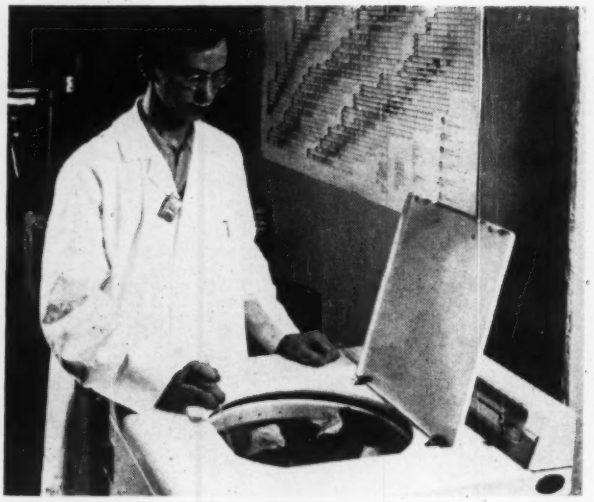
Shown above is the apparatus used at the National Bureau of Standards in determining the velocity of light by infrared measurements on the CO molecule. The infrared source at left was used with the adjacent carbon-monoxide absorption cell to measure wavelengths of rotational lines in the CO absorption spectrum. The high precision required in determining the frequencies of the spectral lines was made possible by grating spectrometer (enclosure, background) designed by Dr. E. K. Plyler, Chief of the Bureau's radiometry laboratory. A Fabry-Perot interferometer (center) provided a comparison spectrum in measurements of the rotational-vibrational lines in the CO spectrum.

Standards Engineers Convention

CAMDEN, N. J.—Latest developments in applying standards to progress in industry, government, and distribution will be discussed at a national convention of the Standards Engineers Society which will take place in Hartford, Connecticut, Sept. 29—Oct. 1. The program chairman is Arnold B. White, Standards Engineer at Veeder-Root, Inc. The convention will open at 9:15 a.m. on Thursday, September 29, with a series of panel discussions. Cyril Ainsworth, Technical Director of the American Standards Association, will speak in the negative on the topic "Should Standards be Mandatory?"

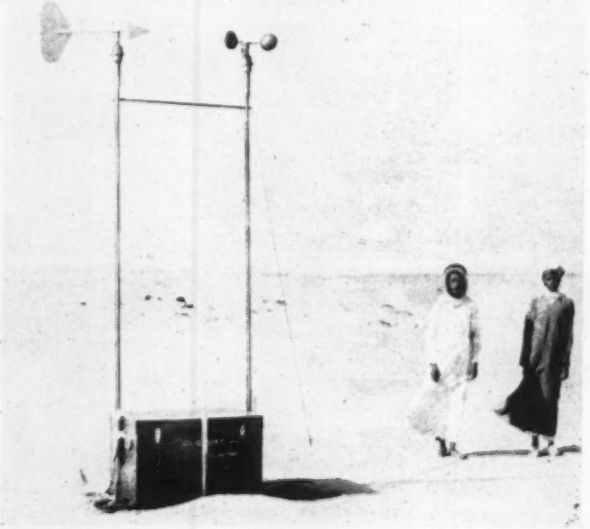
Radioactive "Dirt"

CHICAGO, ILL.—Radioactive dirt is now being used routinely by a number of companies to determine the amount of soil or dirt removed from fabrics under various cleaning conditions. Several kinds of standard test swatches are made available, each containing a spot of radioactive dirt. The radioactivity may be in the form of Carbon-14 tagged protein, carbon black, or fat. The measurement of the radioactivity by a Geiger counter, before, after washing, shows the extent of soil removal in the cleaning operation.



The instrumentation and swatches may be obtained without AEC authorization and may be handled without undue safety precautions because the radioactivity of each swatch is low and non-penetrating. The long half-life of the isotope, C^{14}, and the non-ageing characteristics of the dirt, make possible long storage of the swatches if necessary. The cost of adequate instrumentation for swatch evaluation is about $800, reports Nuclear Instrument and Chemical Corporation, 229 West Erie Street, Chicago, Illinois.

Desert Station

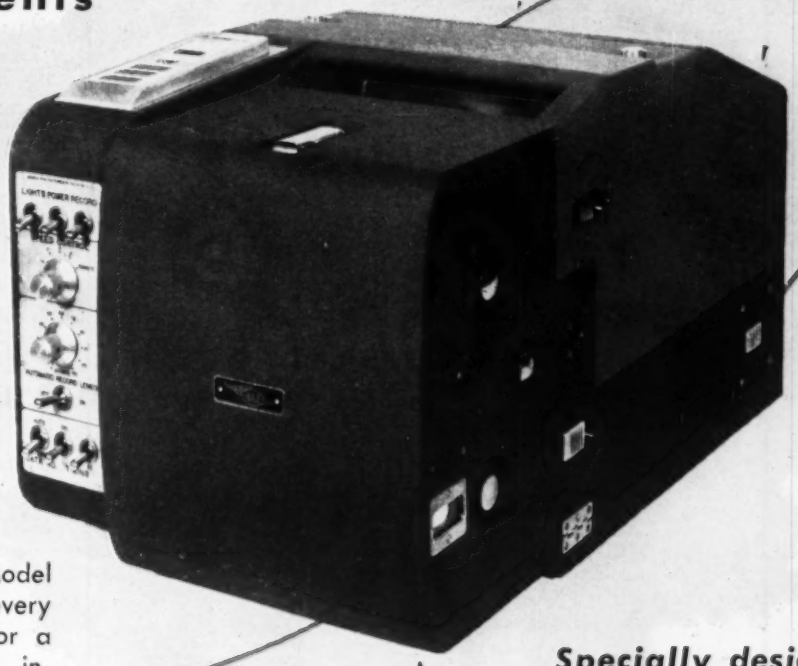


ARABIA—Gurley recording station for wind velocity and direction supplies accurate wind records in Arabian desert. System runs unattended for 15 days.

Emergency Power

MIDLAND, PA.—Interruption of power at the Midland, Pa. mill of Crucible Steel Company of America called this mobile electric set from Caterpillar Tractor Co.,

A uniquely NEW Oscillograph from Midwestern Instruments



Midwestern's New Model 590 incorporates every feature necessary for a successful flight-test instrument.

*Specially designed for remote control**

**If desired the instrument can be supplied with no controls on it. All control then originates at a remote location.*

Here's another great development in Midwestern's series of famous flight-test instruments. It is based on extensive experience applying other Midwestern oscillographs to many combinations of environmental conditions. One of the many features is a remotely-controlled jump-speed system. Speed may be changed at any time by simply positioning a rotary switch to the required setting. 20 recording speeds are possible with this electrically-actuated system and change gears within the oscillograph. Lamp intensities are automatically adjusted to a previously-set value for recording at the new speed. The single aluminum alloy casting is ribbed for the strength and rigidity needed under high acceleration conditions.

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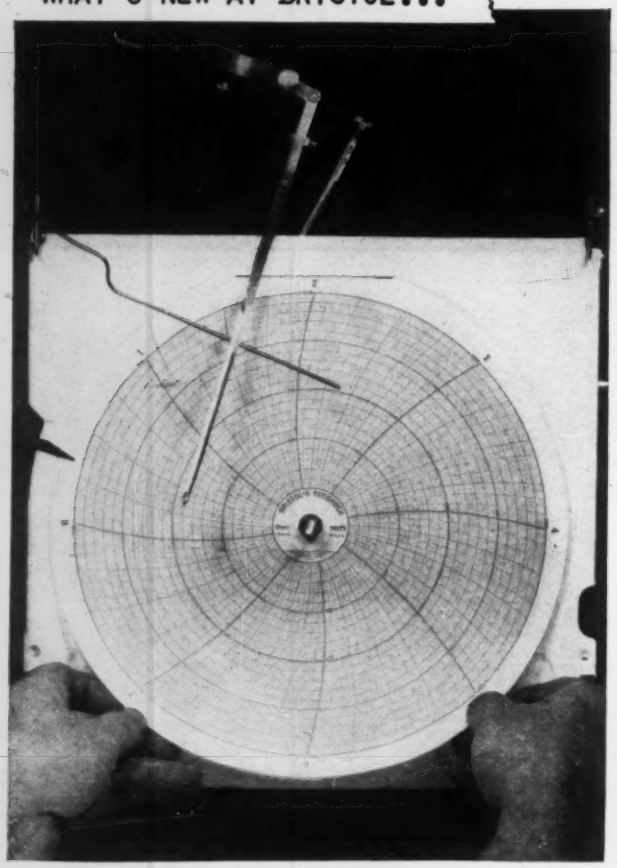

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3. The Bristol Company can provide better service for Bristol Instruments if genuine charts are used. Bristol recorder pens and ink are designed for use with Bristol charts.
4. The Bristol Company cannot guarantee the accuracy of your Bristol recorder if you do not use genuine Bristol charts.

If you want to know more about how important chart quality is, write for our Bulletin Y-1904, "The Bristol Chart Story". The Bristol Company, 113 Bristol Road, Waterbury 20, Conn. 5.10

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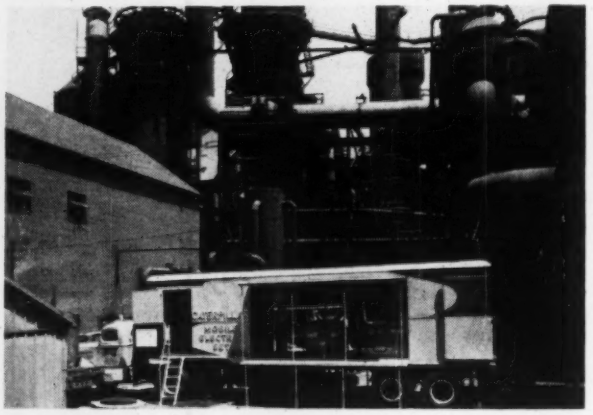
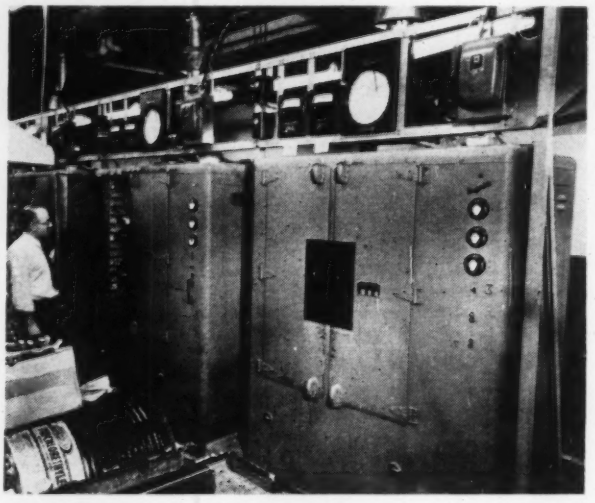
NEWS—CONTINUED



Peoria, Ill. to the rescue. The 500-horsepower mobile unit operated water cooling pumps to prevent blast furnaces from burning out.

Oven Instrumentation

MINNEAPOLIS, MINN.—The 16-hr baking period of plastic resistors and capacitors being baked in these Des-



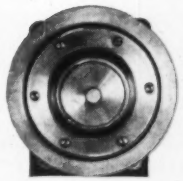
patch V-33 ovens at the Aero Div. plant of Minneapolis-Honeywell is automatically controlled. The instrumentation includes, per oven: 1 Electr-O-Vane recorder-controller, 1 high-limit Pyr-O-Vane, 1 low-limit Pyr-O-Vane, 1 GE timer, 1 set of 3-heat switches (high-low-medium), 1 ElectroniK strip-chart 16-point recorder (serves 3 ovens), 2 magnetic starters, and 1 forced exhaust system.

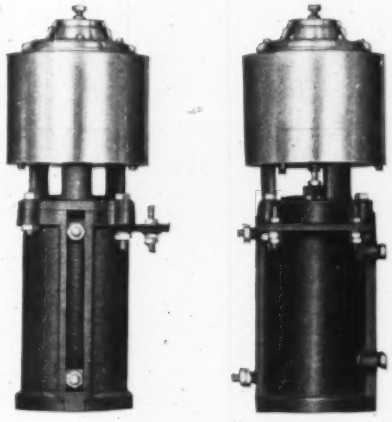
Octagonal-mirror Coating

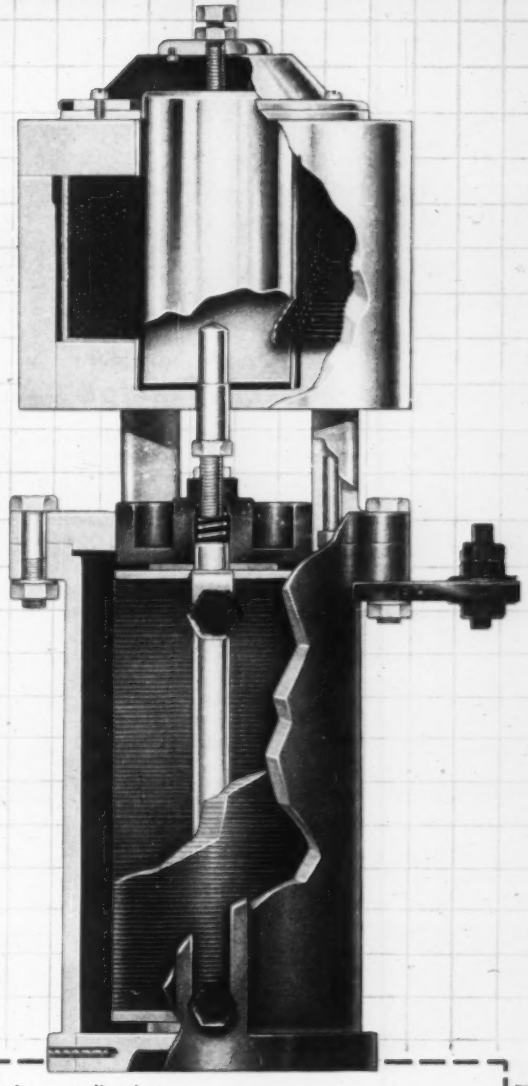
LIVERMORE, CALIFORNIA—This device was designed and constructed by Alfred R. Taylor, U. of Cal. Radiation Laboratory, Livermore, for the purpose of coating the "Model 100" 8-faced metallic rotating mirror with an equal amount of material on each mirror face. Aluminum, silver, gold, tin, and chromium as well as nonmetallic substances may be used as coating materials.

The mirror surfaces are within $\frac{1}{8}$ to $\frac{1}{4}$ interference fringe (argon), of being flat. If the mirror was rotated in an uncontrolled stream of evaporant, more material would

SR-50 CONTROL







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Turn a dial to the speed required and this speed is maintained regardless of line or load variations.

For automatic control the SR-50 may be operated by a sensing element which responds to temperature, pressure, liquid level, tension, acidity or light.

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Send information regarding SR-50 Control Equipment for following application:

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- Built-in mercury commutator for lead resistance compensation
- Sub-panel switch construction
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Described in Bulletin 100

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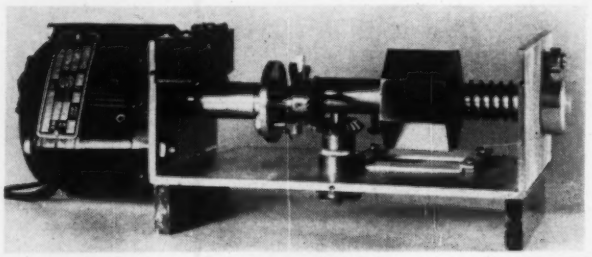


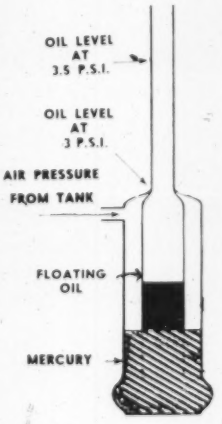
be deposited on the adjoining edges of the flats than in the center area, and the flats would become concave.

The complete assembly is placed in the vacuum-plating apparatus directly above an evaporant source. As the motor turns one revolution, a pin mounted on the motor shaft engages the sprocket mounted on the mirror drive shaft, rotating it ⅛ turn (see arrow); this also rotates the mirror the same distance (⅛ turn). During the time the mirror is being rotated, a synchronized shutter (below the aperture) covers the aperture, interrupting the stream of evaporant to the mirror. When the mirror ceases turning, the shutter uncovers the aperture and the coating process continues until the coating is about 4×10^{-5} inch thick.

The Microswitch cam is set so that it activates a signal light, indicating that the eighth and last side of the mirror is being coated.

Double-fluid Manometer

SAN DIEGO, CALIF.—The Ryan Aeronautical Company of San Diego tests aluminum fuel tanks by subjecting them to a pressure of 3.5 psi for 45 minutes. In order to read pressure changes of 0.002 psi, a water-column manometer is required (1 psi = 27.68″ H_2O, 0.002 psi = 3.5/64″ H_2O). However, a water manometer for 4 psi would be nearly 10 feet high.



W. Alderson, Chief of Ryan's Instrument Lab, used this ingenious trick to reduce the over-all size of the manometer, yet have water sensitivity. Instead of using a conventional capillary in an open reservoir, he placed the reservoir within a closed chamber that is connected to the pressurized system, as shown. Hg is poured into the container and then red manometer oil, with same specific gravity as water, is poured on top of the Hg. Amount of Hg is adjusted carefully so that a pressure of 3 psi raises oil level to the small capillary. Any further increase in pressure causes the oil level to change at a rate of 27.68 inches per psi, as desired. Hence the 3.5-psi pressure can be read with H_2O-manometer sensitivity but the instrument is of Hg-manometer size.

Phila. Controls Air Pollution

PHILADELPHIA, PA.—A $6,500,000 civic waste removal program under way in Philadelphia includes 15 furnaces in four incinerator plants. A Minneapolis-Honeywell automatic control setup achieves effective smoke control by automatically adjusting the incinerator flames.

Continued on page 1409

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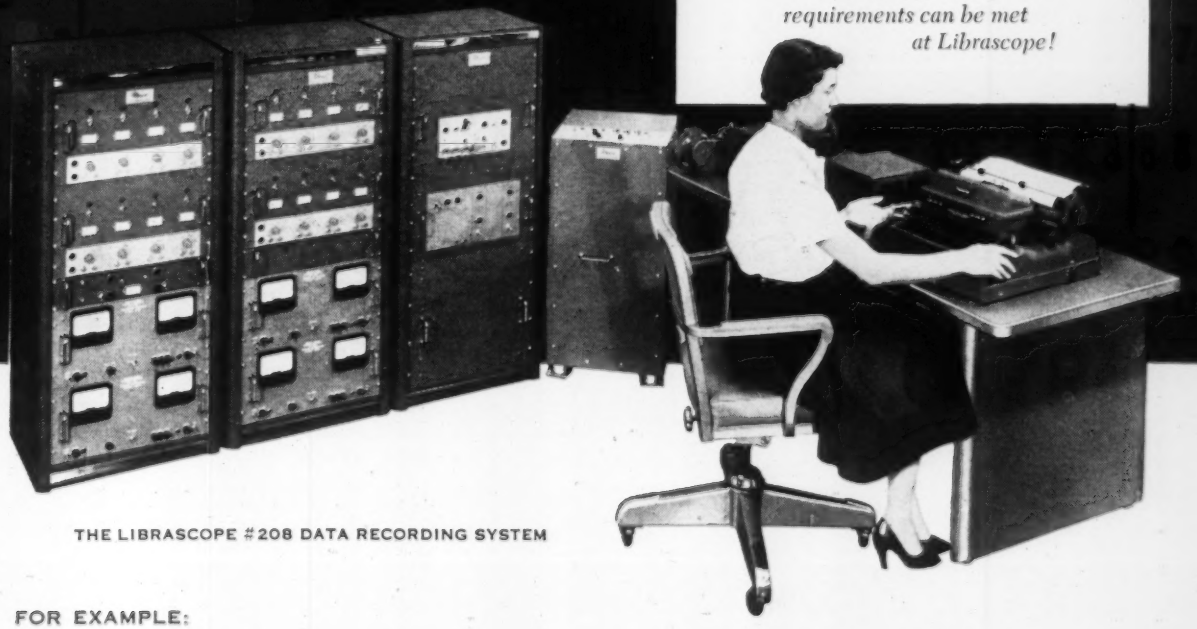

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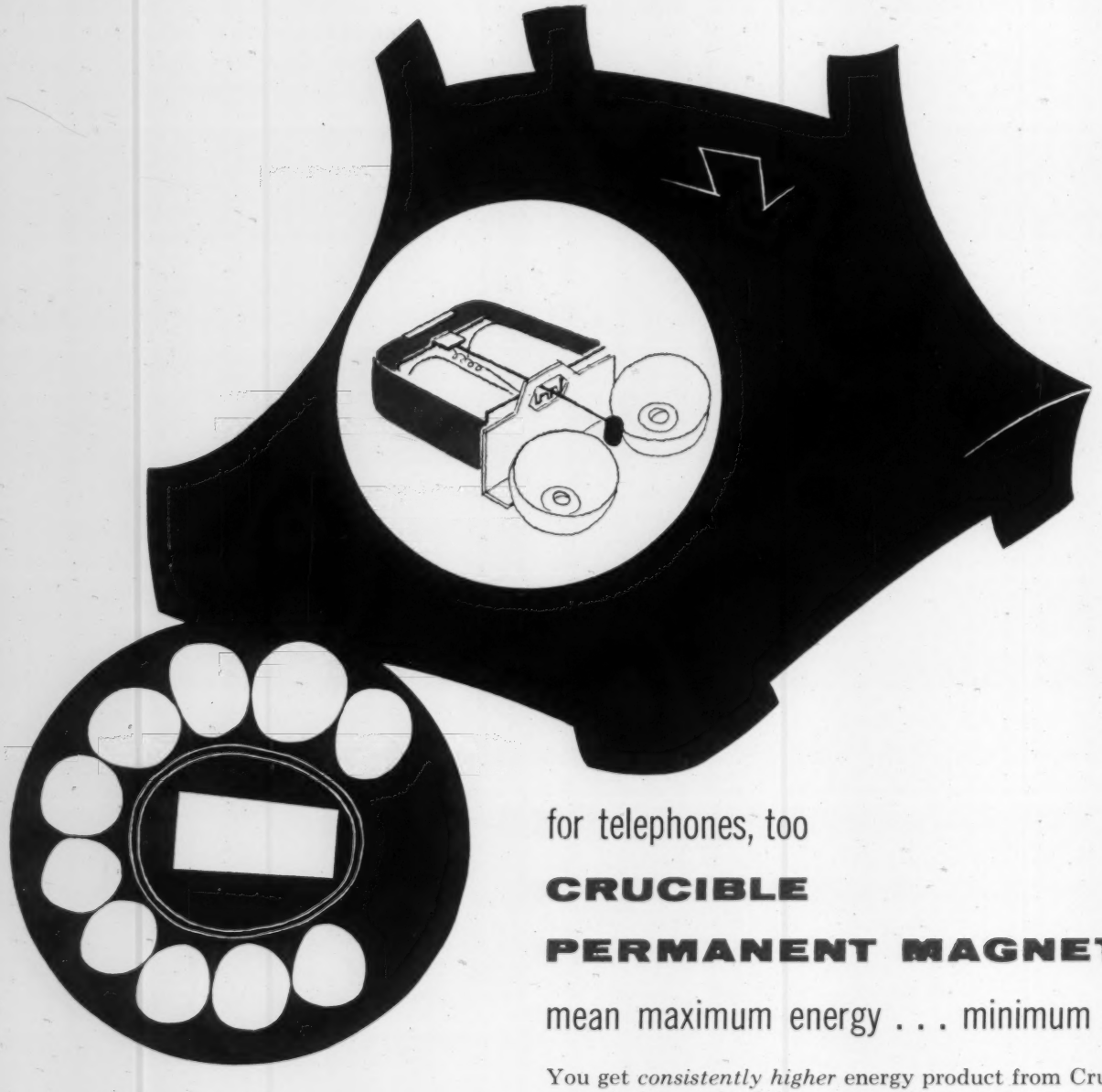

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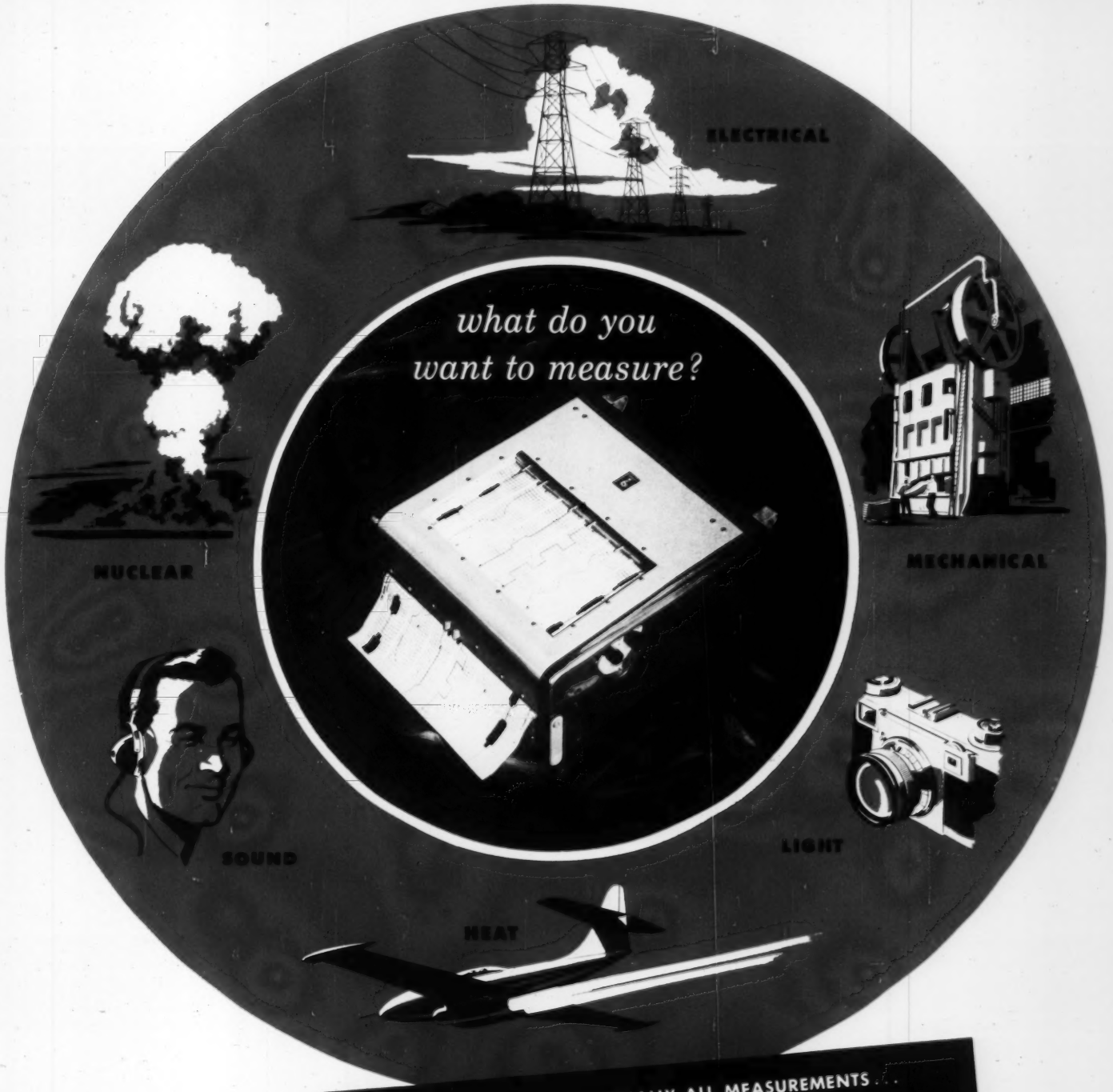

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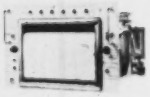
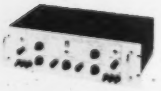


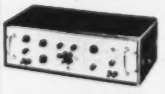
6 channel

1 and 2 channel

AMPLIFIERS



D.C. amplifier



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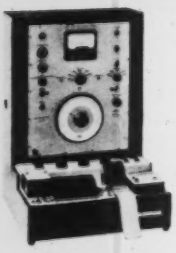
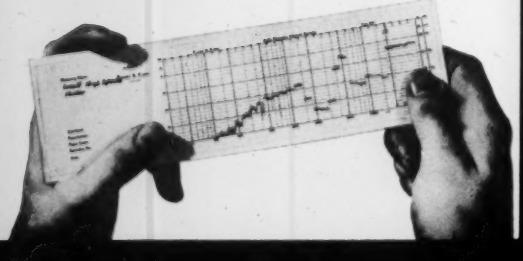
High gain D.C. amplifier

SOUND MEASUREMENT



Brush offers an integrated line of precision equipment for measuring and recording sound, noise, vibration. Typical is the Third-Octave Spectrum Recorder, a self-contained system for simultaneous analysis and recording of vibration and noise.



DIGITAL COUNTING

The Brush Countess* is the lowest-cost high-quality digital counter available, operates on one-fourth the power required by conventional counters.

For complete information or bulletins on Brush equipment write: Brush Electronics Company, Dept. 99, 3405 Perkins Avenue, Cleveland 14, Ohio.

*Trade Mark

BRUSH ELECTRONICS COMPANY

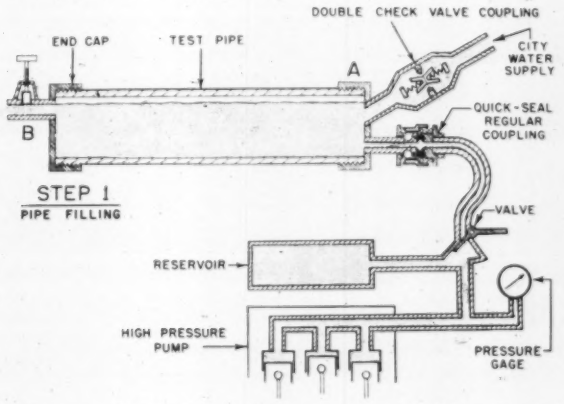
INDUSTRIAL AND RESEARCH INSTRUMENTS
PIEZOELECTRIC MATERIALS • ACOUSTIC DEVICES
MAGNETIC RECORDING EQUIPMENT AND COMPONENTS

BRUSH ELECTRONICS

Division of Clevite Corporation

Coupling Solves Test Problem

PITTSBURGH, PA.—When the API recently adopted a specification requiring that steel tubing used in oil-well drilling be tested to 80% of minimum yield strength, the Pittsburgh Steel Company was faced with the problem of



production testing pipe at pressures to 10,000 psi. The system shown permits filling the pipe with water, applying the test pressure, and then emptying. Key to rapid testing was use of a quick-connect coupling with double-check feature, high strength to resist the test pressure, and non-leaking at the high pressure. The coupling is a product of Titeflex, Inc., Springfield, Mass.

ITV Finds New Uses

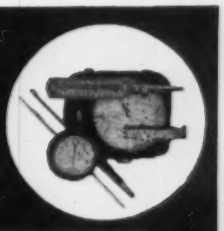
ARCADIA, CALIF.—Use of closed-circuit TV for posting prices and odds at a race track was demonstrated recently at the Santa Anita race track. Win, place and show

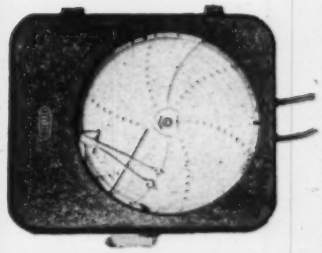
prices were flashed from computing room to TV screen over the cashier's window. The ITV equipment was supplied by Kay Lab.

Another new use of ITV is the control of traffic in a half-mile tunnel piercing a W. Va. mountain. This system was supplied by Dage Television, Cleveland, Ohio.

A recent ITV application in railroading is at the Pennsylvania Railroad terminal building in Pittsburgh, where the movement of rail cars in and out of the post office is monitored by a train director in a control tower 2,000 feet away. This ITV system was supplied by Diamond Power Specialty Corp., Lancaster, Ohio.

when it comes to accuracy install MOELLER dials and recorders





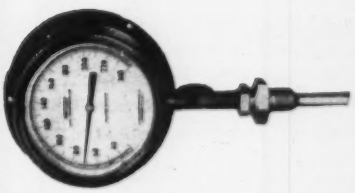
Single and Multiple Pen, Remote Recording Thermometers. Available for one and two temperature recordings in round cases and up to four temperature recordings in rectangular cases.

Representatives in Principal Cities

TEMPERATURE RECORDING TYPE

PORTABLE RECORDING THERMOMETER No. 6025 designed for carrying from one location to another. Convenient ranges up to 180° F. Available with 12, 24 hour or 7 day chart drive.

TEMPERATURE INDICATING TYPE



Adjustable Form Dial Indicating Thermometers with separable socket. Can be quickly adjusted to any angle.

Remote Reading Dial Thermometers, Mercury actuated, with separable socket. Panel or flush mounting.

SINCE 1867 MOELLER INSTRUMENT COMPANY, 132nd St. and 89th Ave., RICHMOND HILL 18, N. Y.

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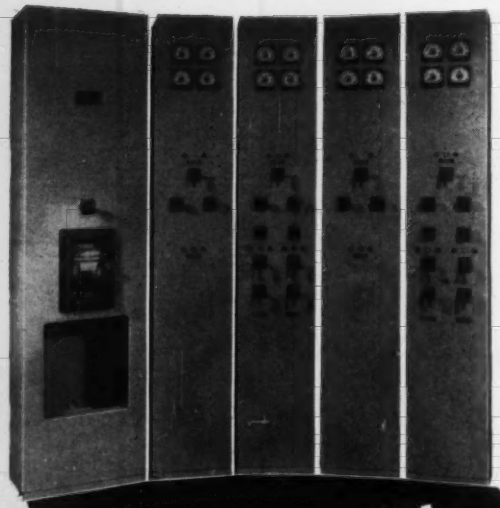
132ND STREET & 89TH AVENUE, RICHMOND HILL 18, N. Y.
Gentlemen: Without obligation, please send me Catalog No. 150 on Moeller Dials and Recorders.
NAME .....
FIRM .....
ADDRESS .....
CITY ..... ZONE ..... STATE .....

For more information circle **25** on inquiry card.



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ONE or one thousand, from a small timer case to a huge control panel, Kirk and Blum produces all kinds of metal enclosures, quickly and economically.

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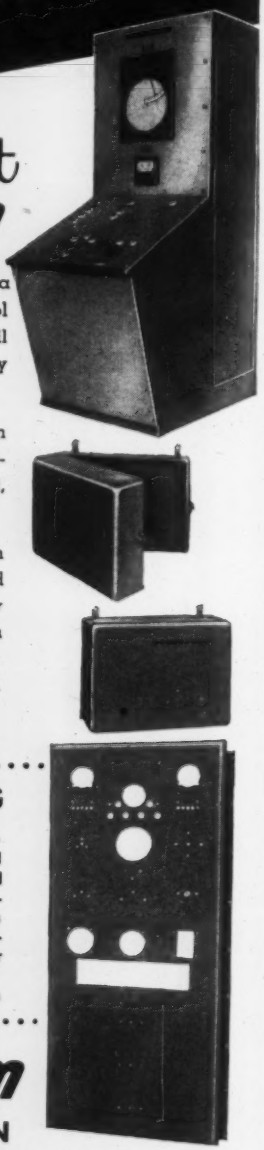


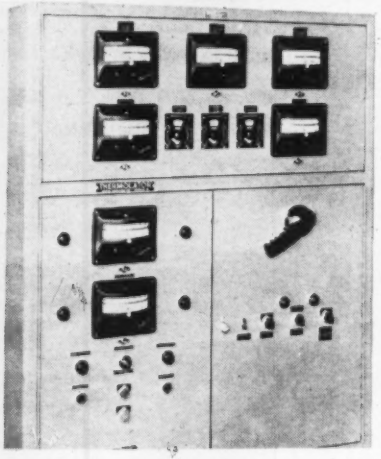
CONTRACT MANUFACTURING FACILITIES for: Control Desks • Boiler, Turbine and Generator Control Panels • Power Distribution and Control Panels • Switch Gear Housings • Cubicles • Instrument Panels • Machine Bases • Electrical Enclosures • Breechings • Transformer Enclosures • Air Ducts • Stacks • Weatherproof Housings • Hoppers

KIRK & BLUM
METAL FABRICATION

For more information circle **26** on inquiry card.

Molding Machine Control

CHICAGO, ILL.—The new Lester 20-oz injection molding machine is controlled by this central control panel. The system includes 5 zone-temperature controllers, 3 timers, 2 mold-temperature controllers, and all electrical components. The panel cabinet was constructed by West In-



strument Corporation, Chicago, who supplied the 5 zone controllers ("Guardsman" proportioning controllers) and timers shown on the upper panel. Machine controls and timers were supplied by Lester-Phoenix, Inc., Cleveland. This is said to be the first unified control system for such machines.

Radio-controlled Traffic

CHICAGO, ILL.—Chicago will soon have the world's most extensive network of radio-operated traffic signals. The system, developed by General Electric Company, utilizes existing stop lights, with automatic program control as required by car movements and traffic conditions. A control station, located in Board of Trade Building will have an antenna 605 feet above ground. Tone signals from the central station will be sent to FM receivers mounted near the lights to retime the lights.

Greeley, Colorado, already has one such system, designed by Colorado Electronics Corporation.

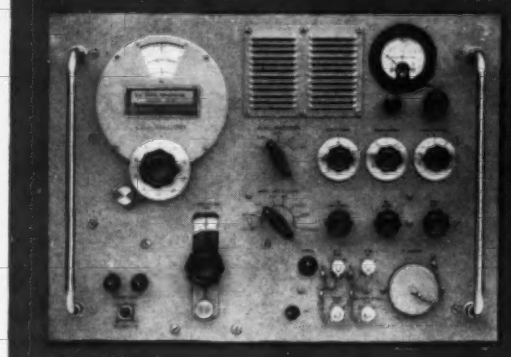
Computer Finds Oil Fields

DALLAS, TEXAS.—Helping to pin-point underground oil traps and diminish the number of dry wildcat wells is one of the first assignments for the $169,000 DATATRON electronic digital computer recently installed at Magnolia Petroleum's Field Research Laboratories in Dallas, Texas. Manufactured by ElectroData Corporation of Pasadena, Calif., DATATRON is the largest computer placed with any U.S. oil company, according to Magnolia officials. A twin computer has been at work for the past five months at the affiliate Socony-Vacuum Oil Company in New Jersey, figuring how to set valves and "fire" stills for most efficient refinery operation.

Future jobs for the machine at Magnolia include (1) determining whether pressure, volume, temperature and fluid viscosity relationships can be locked into a set of useful inter-relations; (2) analyzing material quality to aid in designing production tools; (3) assessing equipment performance; (4) calculating statistical production

Direct reading, wide range, outstanding value

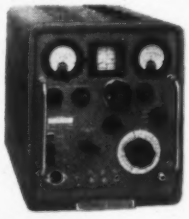
SIGNAL GENERATORS



NEW! -hp- 628A shf Signal Generator

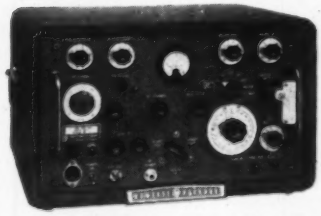
15 to 21 KMC, 10 dbm output
SWR 1.2, high accuracy
No calibration charts
Pulse, FM, square wave modulation

Typical -hp- signal generators



-hp- 608D vhf Signal Generator

-hp- 612A uhf Signal Generator



-hp- 624C X Band Test Set

New -hp- 628A is the first commercial signal generator to bring the wide range, high power, convenience and accuracy of lower-frequency signal generators to the 15 to 21 KMC range.

Operation of the instrument is typical of -hp- generators. Frequencies are directly set and read on one dial. No calibration charts are required. Output voltage is directly set and read. Output is 10 to 20 db better than previous spot-frequency generators. SWR is better than 1.5 at full power, and better than 1.2 at levels of +7 dbm and less. Internal pulse, FM or square wave modulation is provided, together with provision for external pulsing or FM'ing. Model 628A, $3,000.00.

Instrument	Frequency Range	Characteristics	Price
-hp- 608C	10 to 480 MC	Output 0.1 μv to 1 v into 50 ohm load. Pulse or CW modulation. Direct calib.	$ 950.00
-hp- 608D	10 to 420 MC	Output 0.1 μv to 0.5 v. Incidental FM 0.002 entire range.	1,050.00
-hp- 612A	450 to 1,200 MC	Output 0.1 μv to 0.5 v into 50 ohm load. Pulse, CW or square wave modulation. Direct calibration.	1,200.00
-hp- 614A	800 to 2,100 MC	Output 0.1 μv to 0.223 v into 50 ohm load. Pulse, CW or FM modulation. Direct calib.	1,950.00
-hp- 616A	1,800 to 4,000 MC	Output 0.1 μv to 0.223 v into 50 ohm load. Pulse, CW or FM modulation. Direct calib.	1,950.00
-hp- 618B	3,800 to 7,600 MC	Output 0.1 μv to 0.223 v into 50 ohm load. Pulse, CW, FM or square wave modulation. Direct calibration.	2,250.00
-hp- 620A	7,000 to 11,000 MC	Output 0.1 μv to 0.071 v into 50 ohm load. Pulse, FM or square wave modulation. Separate power meter and wave meter section.	2,250.00
-hp- 623B	5,925 to 7,725 MC	Output 70 μv to 0.223 v into 50 ohm loa l. FM or square wave modulation. Separate power meter and wave meter section.	1,750.00
-hp- 624C	8,500 to 10,000 MC	Output 3.0 μv to 0.223 v into 50 ohm load. Pulse, FM or square wave modulation. Separate power meter and wave meter section.	2,265.00Δ

Data subject to change without notice.

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3340C PAGE MILL ROAD • PALO ALTO, CALIF.

ΔRack mounted instrument available for $15.00 less.

hp COMPLETE COVERAGE, HIGHEST QUALITY

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all shapes . . all sizes . . all grades . .

CAST ALNICO . . SINTERED ALNICO . . HYFLUX ALNICO V HE . . INDOX CERAMIC MAGNETS . . CUNIFE . . AND OTHER SPECIAL MAGNET MATERIALS

FREE TECHNICAL HELPS:

If you are interested in obtaining magnets for your experimental work, write for Catalogs 11-D-9 or 12-D-9 which list a wide range of stock magnets available for immediate shipment. Catalog 11-D-9 covers *cast* permanent magnets . . . Catalog 12-D-9 covers *sintered* permanent magnets.

Also available without charge is a subscription to the publication, "Applied Magnetics." You should receive this publication if you're interested in or responsible for the design or development of products using permanent magnets.

Please send requests on your company letterhead

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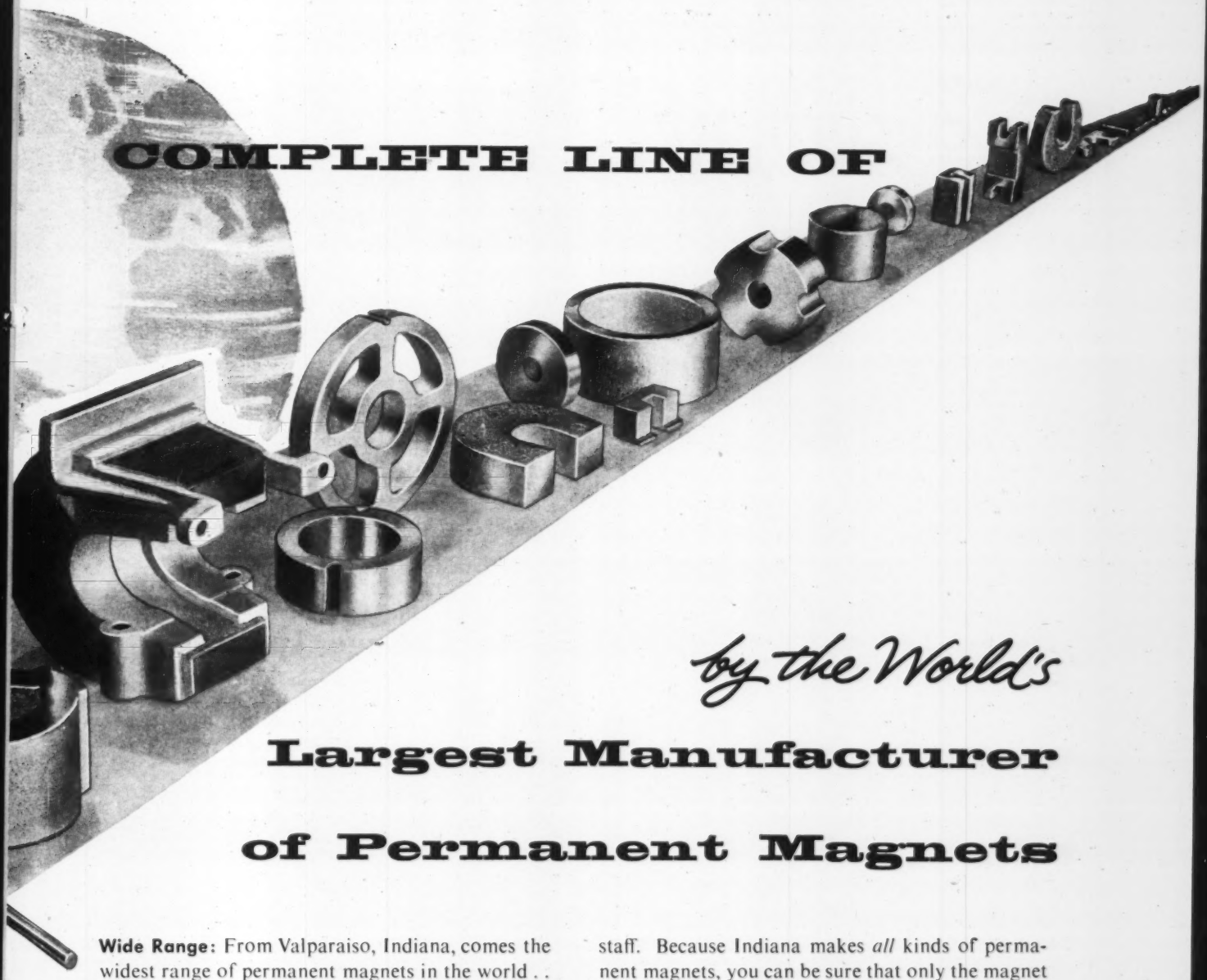

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by the World's

Largest Manufacturer of Permanent Magnets

Wide Range: From Valparaiso, Indiana, comes the widest range of permanent magnets in the world . . from tiny "U"-shaped 1/10 oz. sintered Alnico permanent magnets to massive cast magnets weighing 1,000 pounds, and more! Many standard sizes and shapes are available from stock . . and quickly . . in 24 hours!

Largest Engineering Staff: For your special permanent magnet applications, Indiana offers the World's largest engineering staff devoted solely to the design and application of permanent magnets. This staff, backed by the World's largest and most complete magnetic research and production facilities, is available to consult with your own design engineering staff. Because Indiana makes *all* kinds of permanent magnets, you can be sure that only the magnet best suited to your product's requirements will be recommended.

Magnetic Specialists: Indiana Steel Products Co. has concentrated on manufacturing magnetic materials for almost half a century. All facilities, attention, and effort are channeled to magnetic materials . . and *only* to magnetic materials.

Trained Sales Engineers: Indiana Permanent Magnet salesmen are trained engineers. Frequently they are in a position to give your technical men on-the-spot suggestions. More often than not, they have already encountered problems similar to yours.

THE INDIANA STEEL PRODUCTS COMPANY

VALPARAISO, INDIANA

World's Largest Manufacturer of Permanent Magnets

INDIANA PERMANENT MAGNETS

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Announcing the

CIRCUITRON*

$29.00

FOR

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PRODUCTION-PROTOTYPES
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HOBBYISTS
"HAMS"
AMPLIFIERS

GENERAL

The "Circuitron" consists of a steel chassis foundation incorporating an electronically regulated power supply and a removable 10" x 10" aluminum "breadboard." It provides a compact, variable, regulated power supply on a chassis with room for any basic circuit.

Banish forever: makeshift wiring; bulky external power supplies; dangerous exposed load resistors; stray capacitance effects and other annoyances. BUILD IT RIGHT THE FIRST TIME!

SPECIFICATIONS

Max. Reg. Voltage: 350 V.D.C.
Max. Reg. Current: 60 M.A.
Max. Unreg. Voltage: 350 V.D.C.
Max. Unreg. Current: 60 M.A.
Regulation 105-125: ± 1%
Ripple at no load: 1 Millivolt
Reg. Full-load range: 150-300 V.D.C.
Fil. Voltage: 6.3 C.T. at 3 Amps.

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MORROW PRODUCTS INC.
Pittsburgh 13, Penna. *T.M. REG.

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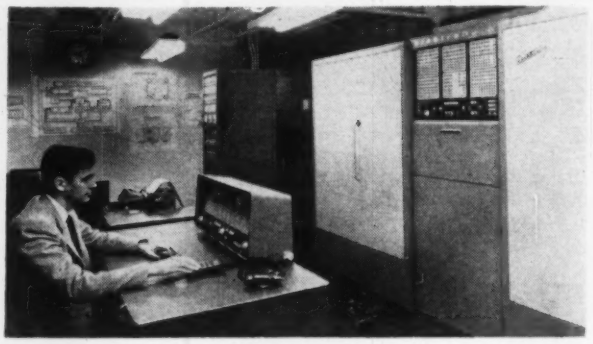
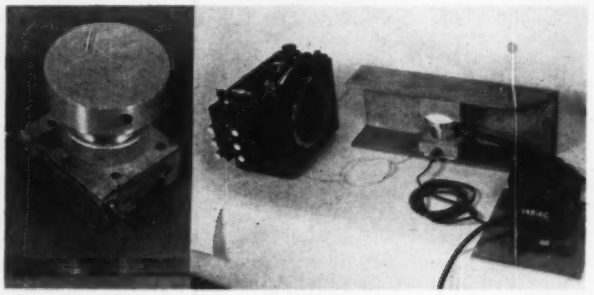


information, such as estimated crude oil runs; (5) studying the relationships between grain size, porosity, composition, etc. of oil sand grains; and (6) predicting future behavior of oil reservoirs.

In less than one production year at ElectroData Corporation, eleven DATATRONS have been installed nationwide. Users include Allstate Insurance Company, Purdue University, Land Air, Inc., Jet Propulsion Laboratory of CalTech, Arma Div. of American Bosch Arma Corp., and the U.S. Naval Ordnance Lab., Corona, Calif.

Strain-Gage Applicator

SEATTLE, WASH.—S. W. Leszynski, Research Engineer of Boeing Airplane Co., Seattle, has reported (in a paper before the SESA in Los Angeles) the development



of an applicator for installing Bakelite-type strain gages. The applicator consists of a pneumatic pressure actuator plus a heater assembly. The pressure actuator is an air-activated piston. The actuator has been used for simplifying and accelerating the application of Bakelite-type and paper-type bonded strain gages at Boeing. The applicator is shown at left. At right it is shown in use, bonding strain gages to a simulated wing spar.

Irradiated Polyethylene

PITTSFIELD, MASS.—What is believed to be the first commercial application of irradiated polyethylene was announced by General Electric Company's Chemical Development Department, which has developed a new form of the irradiated plastic for use as turn insulation on circuit breakers. G-E Irrathene 201 irradiated polyethylene—a new stabilized type of irradiated polyethylene tape—has been announced by the Chemical Development Department, Pittsfield, Mass., and put to use by G. E.'s Switchgear and Control Division as turn insulation for blowout coils on its Magne-Blast circuit breakers.

For the THIRD INTERNATIONAL AUTOMATION EXPOSITION

New York City, November 26-30, 1956

A NEW TRADE SHOW BUILDING

at 500 Eighth Avenue, New York City

Third International Automation Exposition will occupy five floors—2nd, 3rd, 4th, 5th, and 6th.

Rest rooms on each floor . . . water coolers in four corners of each floor . . . restaurant and bar in the building.

A NEW TRADE SHOW CONCEPT

Each "booth" an individual **air-conditioned** room . . . can be locked at close of show each day . . . . each exhibit **visible** from hall.

Refreshments can be served **in** the rooms; also will be available from serving carts **during open hours of the Show.**

Special shelving for each room optional at NO CHARGE . . .

Exhibitor personnel may set up **own exhibit;** additional labor also available through the service desk . . .

Crate storage in basement **or in exhibitor's own display room.**

AUTOMATION HANDBOOK

FREE space (7x10" page for each booth) in the HANDBOOK enables all exhibitors to describe the products in their exhibit—thereby extending the effectiveness of their participation in the Show. All registrants receive a copy.

A NEW LOW COST FOR EXHIBITORS

All-inclusive price of $4.50 per square foot includes: Handling exhibit material from receiving platform of building to your booth; electric current (to 3,000 watts); general lighting (about 50 foot-candles); one spotlight; furniture (4 tables, 4 chairs, 1 smoking stand, 1 costumer); telephone; crate storage; name sign; asphalt tile floor; cleaning; and handling exhibit material from booth to shipping platform at end of show.

*Second floor is an open exhibit area laid out in usual booth style . . . Furniture, spotlight, and telephone not included in these booths.

Exhibitors in the Second International Automation Exposition have a priority in the choice of their exhibit space at the Third International Automation Exposition, New York City, November 26-30, 1956.

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500 Eighth Avenue, between 35th and 36th Streets, New York City.
One block from the Pennsylvania and Long Island Railroad Stations
Tunnel connection from Station, Statler Hotel, and 7th Avenue Subway

8th Ave. Subway Station at corner
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2 blocks from Statler Hotel
3 blocks from Governor Clinton Hotel
4 blocks from West Side Highway
4 blocks from Lincoln Tunnel
5 blocks from International Bus Station
8 blocks from Queens Midtown Tunnel
8 blocks from Domestic and West Side International Air Terminals
15 minutes from Grand Central Station
20 minutes from Washington Bridge

for more information, write, wire, or phone:

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845 RIDGE AVENUE
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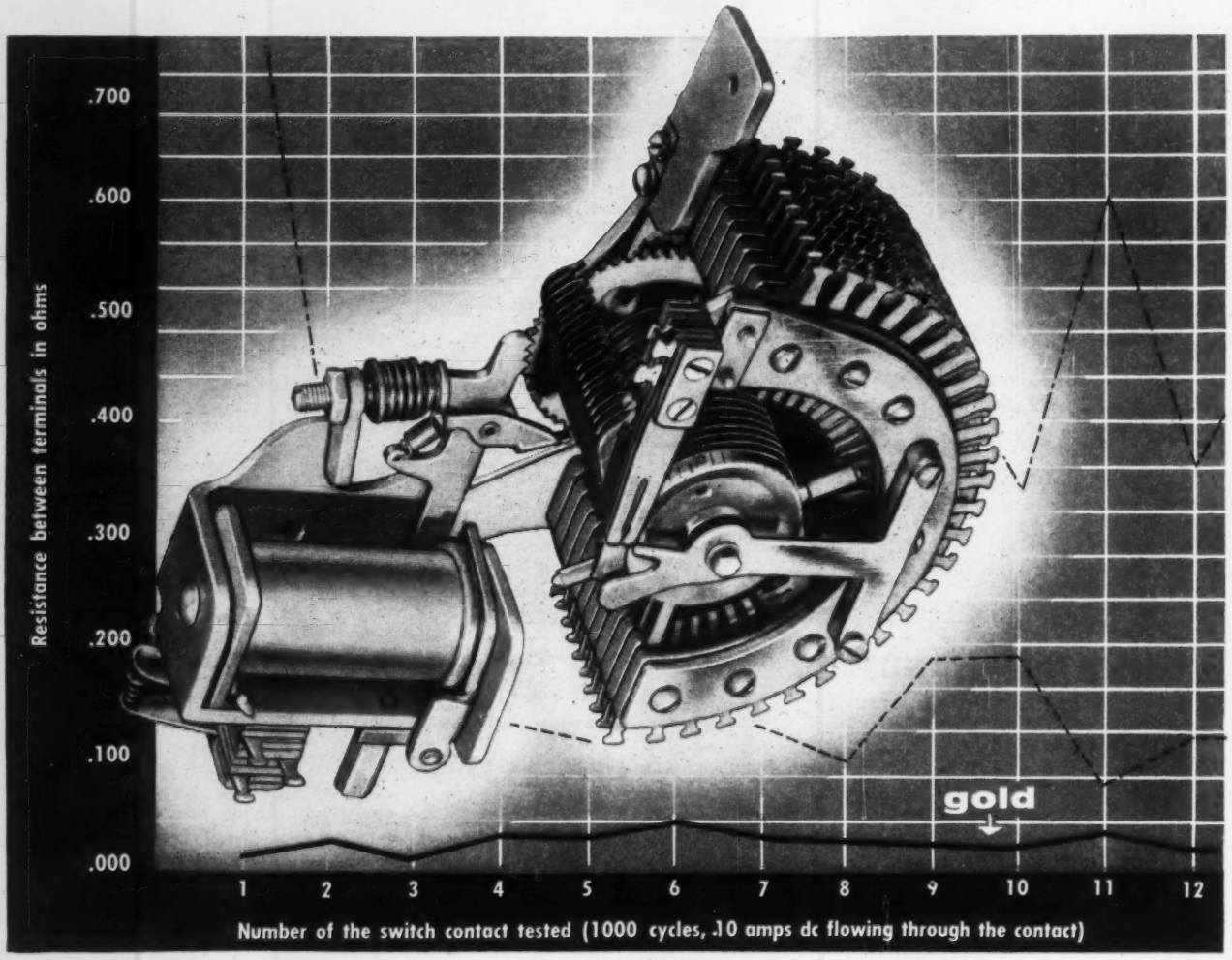
Phone:
FA-1-9831

Why instrument men use Automatic's Switches with precious metal contacts



More and more instrument engineers are specifying gold-plated or silver-inlaid contacts for:

- *thermocouple monitoring*
- *strain-gauge readings*
- *infrequently operated devices such as submarine mine detonators*
- *low-power-level circuits, as in computors*
- *many other uses where extremely low resistance is essential*

Instrument men find that, in measurement, indication and supervisory functions, precious-metal contacting provides:

- accuracy at lowest potentials
- low, and relatively constant, contact resistance
- freedom from spurious potentials which can, under some conditions, be set up by base-metal contacts

Precious-metal contacting costs more, of course. But with Automatic Electric's custom designing, it is not as expensive as you might think; on either Type 44 or Type 45 switches, you can specify precious-metal contacts for instrument circuits only, with standard contacts handling the less important circuits.

For full information on the use of stepping switches—*with or without* precious-metal contacts, ask for Circulars 1641 and 1698. *Write:* Automatic Electric Sales Corporation, 1033 W. Van Buren St., (HAymarket 1-4300) Chicago 7, Illinois. *In Canada:* Automatic Electric Sales (Canada) Ltd., Toronto. *Offices in principal cities.*

RELAYS SWITCHES

AUTOMATIC ELECTRIC

CHICAGO

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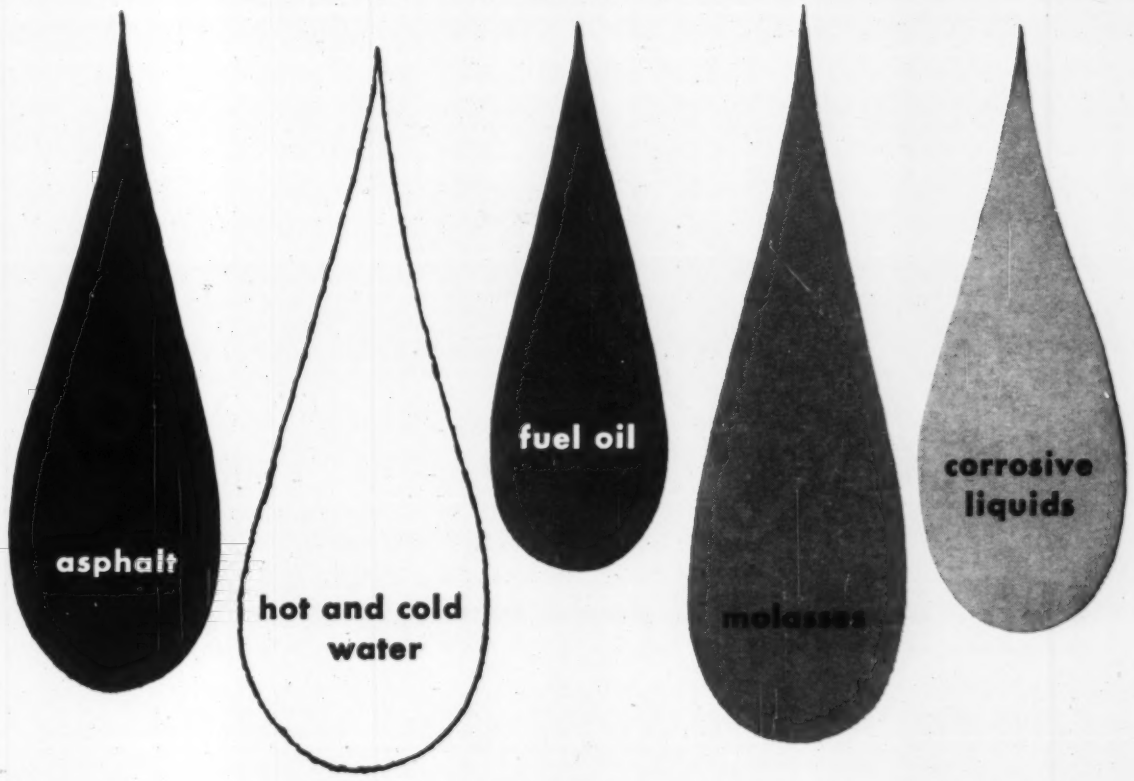
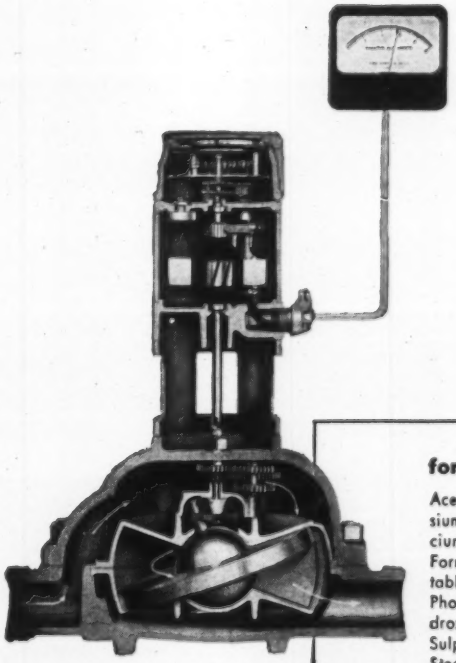
viscosities unlimited



HAYS VERIFLOW METER AND HAYS ELECTRONIC VERITROL

indicate and control liquid flow



Now virtually all fluids can be precisely measured and accurately controlled—*from a remote position.*

Hays VERIFLOW meter accurately measures, indicates, and totals the flow of corrosive and hard-to-meter liquids without using weigh tanks, orifice plates, or gage sticks.

With the Hays VERITROL you simply set a knob at the rate of flow desired . . . then, the VERITROL controls the flow of liquid at that set-rate.

Send for a complete description of Hays Veriflow Meter and Veritrol, Pub. No. 53-766-38.

for corrosive liquids

Acetic Acid, Aluminum Potassium Sulphate, Ammonia, Calcium Compounds, Carbolic Acid, Formaldehyde, Fruit and Vegetable Juices, Hydrogen Peroxide, Phosphoric Acid, Potassium Hydroxide, Sodium Compounds, Sulphuric Acid (concentrated), Stearic Acid, and many others.

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Gas Analyzers • Draft Gages
Combustion Test Sets • CO_2 Recorders
Electronic Oxygen Recorders
Electronic Flowmeters
Electronic Feed Water Controls
Miniature Remote Indicators

THE hays CORPORATION

MICHIGAN CITY 8, INDIANA

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This Bailey Armortube* Cable can save you time and money

With this new material especially designed for pneumatic connecting lines you can make better instrument and control installations in less time and at less cost. Here's why:

Simple — Standard ARMORTUBE* cable is stocked in three convenient sizes: bundles of four, eight, or twelve ¼ inch O.D. aluminum alloy or copper tubes. Other sizes are available on special order. It's a ready-made, fully protected piping material for transmitting pneumatic signals between measuring units, instruments, and control units.

Safe — The flexible metallic covering guards against every hazard, internal or external. Patented rope-like arrangement of tubes eliminates danger of collapse at sharp bends—and damage from external blows or vibration is minimized by protective outer covering.

Compact — All necessary lines can be snaked through tight quarters or around corners with a minimum of connections. No need for unsightly, bulky channels, racks or other special mountings.

Economical — Installation is fast. 100 foot coils and 500 foot reels permit long unbroken runs. Colored tracer simplifies connections at terminals. Slightly higher first cost is quickly amortized by savings in materials, and installation time. For further information and specifications ask for Bulletin and Price List G91-9.

P-30

* Registered Trade Mark

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For Power And Process

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NO LEAKAGE
NO CONTAMINATION
NO STUFFING BOX

Lapp PULSAFEEDER
CONTROLLED-VOLUME CHEMICAL PUMP

Lapp Pulsafeeder is a combination piston-diaphragm pump for controlled-volume pumping of fluids. Reciprocating piston action provides positive displacement. But the piston pumps only a hydraulic medium, working against a diaphragm. A floating, balanced partition, the diaphragm isolates chemical being pumped from the working pump parts—eliminates need for stuffing box or running seal. Pumping speed is constant; variable flow results from variation in piston-stroke length—controlled manually by hand-wheel, or, in Auto-Pneumatic models, by instrument air pressure responding to any instrument-measurable processing variable.

WRITE FOR BULLETIN 440 *with typical applications, flow charts, description and specifications of models of various capacities and constructions. Inquiry Data Sheet included from which we can make specific engineering recommendation for your processing requirement. Write Lapp Insulator Co., Inc., Process Equipment Div., 511 Wilson St., Le Roy, N.Y.*

Lapp

For more information circle **34** on inquiry card.

Here's the Complete "Package"

for Counting Electrically...

Added Evidence that —

Everyone Can Count on VEEDER-ROOT

This Veeder-Root Reset Magnetic Counter (AC or DC) is actuated through electromagnets. And it may be connected in series with any device having a contact arrangement . . . like the specially designed Veeder-Root Electrical Contactor at the left, which insures positive operation of the counter, either in oscillation or connected directly to a revolving shaft . . . with the counter placed at *any* distance from the machine or process on which the count is required.

This is another one of the hundreds of Veeder-Root Standard and Special Counting and Computing Devices developed for every conceivable counting duty, in every field from atomics to electronics.

What do *you* need to count? Just write:

VEEDER-ROOT INCORPORATED
HARTFORD 2, CONNECTICUT

Chicago 6, Ill. • New York 19, N. Y. • Greenville, S. C.
Montreal 2, Canada • Dundee, Scotland
Offices and Agents in Principal Cities
"The Name that Counts"

For more information circle **35** on inquiry card.

It's not too late . . .

You've still time to reserve exhibit space for the Second

INTERNATIONAL AUTOMATION EXPOSITION

CHICAGO NAVY PIER, Nov. 14-17, 1955

HERE ARE THE EARLY-BIRD FIRMS who have already—as of August 25 reserved space:

Advance Electric & Relay Co.
A'G'A' Div., Elastic Stop Nut Corp.
Allegany Instrument Co.
American Etamic Corp.
American Helicopter Div., Fairchild Engine Corp.
American Television & Radio Co.
Analytical Measurements, Inc.
Assembly Products, Inc.
Atomic Instrument Co.
Austin Company
Automatic Electric Sales Company
Automation Consultants
Automation Engineering Lab.
A-V Manufacturing Corp.
Avion Instrument Corporation
Baker Co.
Beede Electrical Instrument Co.
Bendix Computer Division
Berkeley Div., Beckman Instruments
Bowmar Instrument Corporation
Brinkmann & Co., C. A.
Burndy Engineering Co.
Byron Jackson Company
Chainveyor Corp.
C. P. Clare & Company
Clary Multiplier Corp.
Clevite Brush Development Co.
Coleman Engineering Company
Comar Electric
Computer Control Co., Inc.
Counter and Control Corporation
Crawford Fitting Company
Dage TV Division, Thompson Products
Davies Laboratories
Detectron Corp., Computer-Measurements Div.
Dialight Corporation
Doelcam Division, Minneapolis-Honeywell
Dubois Engrg. & Mfg. Co.
Du Mont Laboratories, Inc., A. B.
Dynamic Gear Company
Eastern Precision Resistor Corp.
Eder Instrument Company
Electric Indicator Co.
Electric Regulator Corporation
Electronic Associates
Electronic Control Systems, Inc.
Electro Snap Switch & Mfg. Co.
Elematic Equipment Corporation
Encyclopedia Britannica
Epsco, Inc.
Eriez Manufacturing Company
ETA Products
Farrand Optical Co., Inc.
Feedback Controls, Inc.
Femco, Inc.
Ferrara, Inc.
Fischer & Porter Company
Gaertner Scientific Corporation
Gaudreau Rimbach Assoc.
General Mills Mechanical Division
General Precision Labs.
G. M. Giannini & Company, Inc.
Russell T. Gilman, Inc.
Globe Industries, Inc.
Goodyear Aircraft Corp.
Loren F. Green & Assoc.
Guardian Electric Mfg. Co.
Gurley Co., W. & L. E.
Hammarlund Manufacturing Co.
A. W. Haydon Company
Hays Corporation
Heat Timer Corporation
Karl Heitz, Inc.
Hoke, Inc.
Howard Industries
Hycon Manufacturing Company
Industrial Control Panel Company
Industrial Timer Corp.
Institute of Radio Engineers
Instrument Development Labs., Inc.
Instruments Publishing Company
International Business Machines Co.
International Standard Trading Corp.
James Vibrapower Co.
Kaye Development
Kay Electric Co.
Kellogg Switchboard & Supply Co.
Kleinschmidt, Inc.
Kulka Electric Mfg. Co.
J. B. Lansing Co.
Larson Instrument Company
Lehigh Chemical Products Co.
Leland Co., G. H.
Librascope, Inc.
L. & O. Research & Dev. Co.
Logistics Research Co.
Magnasync Mfg. Co., Ltd.
Magnecraft Electric Co.
Mechanical Handling Systems, Inc.
Magnetic Research Corp.
Micro Switch Div., Minneapolis-Honeywell Regulator Co.
Metrotype Corp.
Molan Motors & Coil Co.
Moog Valve Co., Inc.
Morrow Products Inc.
Mycalex Corporation of America
Nash Engineering Co.
National Cash Register Co.
North American Aviation Corp.
North American Mfg. Co.
North Electric Mfg. Co.
Optronics
Pak-Rapid, Inc.
Panellit, Inc.
Pedersen Electronics Co.
PIC Design Corp.
Polarad Electronics Corp.
Post Machinery Co., Electronic Prod. Div.
Potter & Brumfield Mfg. Co.
Potter Instrument Company
Precision Scientific Company
Production Instrument Company
Radio Frequency Labs., Inc.
J. B. Rea Company
Republic Manufacturing Company
Revco, Inc.
Saffro-Gettleman Co.
Sensitive Research Instrument Co.
Simpson Electric Co.
Sorensen & Co., Inc.
Soroban Engrg., Inc.
Spencer Mfg. Co.
Standard Electrical Products Co.
Standard Electronics Co.
Standard Electronics Research Corp.
Sterling Mfg. Co.
Streeter-Amet Company
Stromberg Carlson Co.
Superior Electric Company
Surprenant Manufacturing Co.
Swiss Jewel Co.
Techniflex Corporation
Teleregister Corp.
Telex, Inc.
Tube Turns Plastics, Inc.
Uehling Instrument Company
Veeder-Root, Inc.
Victor Adding Machine Company
Webb Co., Jervis B.
Weckesser Company
West Instrument Company
Wheelco Div., Barber-Colman Co.
Wollensak Optical Co.
Zenith Electric Company

Exhibitors will receive FREE space (1 page for each booth) in the AUTOMATION HANDBOOK in which to describe and picture their products display. The HANDBOOKS, printed before the Show, are given to each registrant, providing a valuable review of the Show for months to come.

AUTOMATION is too BIG to be just a part of another show . . . More than 15,000 top executives and engineers will visit the only show devoted exclusively to the world of automatic production—automation.

TECHNICAL EVENTS, conferences, meetings, etc., which will be held in Chicago during the Show week are certain to spark Show attendance:

AMERICAN SOCIETY OF MECHANICAL ENGINEERS
Annual Meeting—75th Anniversary

UNIVERSITY OF CHICAGO
2-day Conference on Office Automation
Attendance limited to top executives

ARMED SERVICES CHEMICAL ASSOCIATION
Midwest Chapter—Conference on Electronic Computers

AUTOMATION SHOW MANAGEMENT
will conduct its own clinics on:

- *Electronic Computers (9 Clinics)*
- *Conveyors (6 Clinics)*

For Exhibit Area Floor Plan and Registration Form:

WRITE, WIRE,

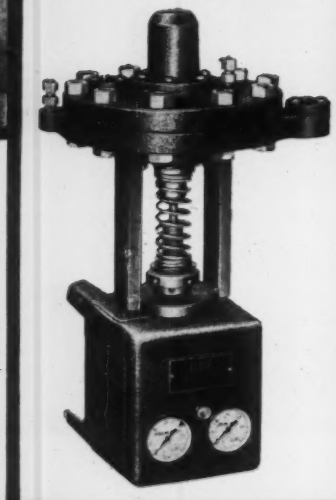
SECOND INTERNATIONAL AUTOMATION EXPOSITION

c/o Richard Rimbach Associates, Mgmt., 845 Ridge Ave., Pittsburgh 12, Pa.

or PHONE FAirfax 1-9831

Here's the *pilot* with the *sense* to save *dollars*

Close Control



Leslie Type LA-2
Level Control Pilot

LESLIE FLOATLESS LEVEL CONTROL Pilots sense changes in liquid level that will help you maintain peak output. You save maintenance dollars, too — forget troublesome floats and cages (there aren't any).

With low resolution sensitivity (.1 of an inch change in level creates response), you are assured of smooth, throttling action and a closely held level.

You'll find Leslie Floatless Level Control Pilots in storage tank, boiler level and process vessel service — in fact, in any liquid level service where accuracy and dependability are important.

There are Leslie Pressure Control and Temperature Pilots with the sense to save dollars in pressure and temperature control stations, too. Your Leslie Engineer, listed under "Valves or Regulators" in your classified directory, will be glad to help you.

Send for Bulletin 5303 on Leslie Control Pilots

TRADE LESLIE MARK

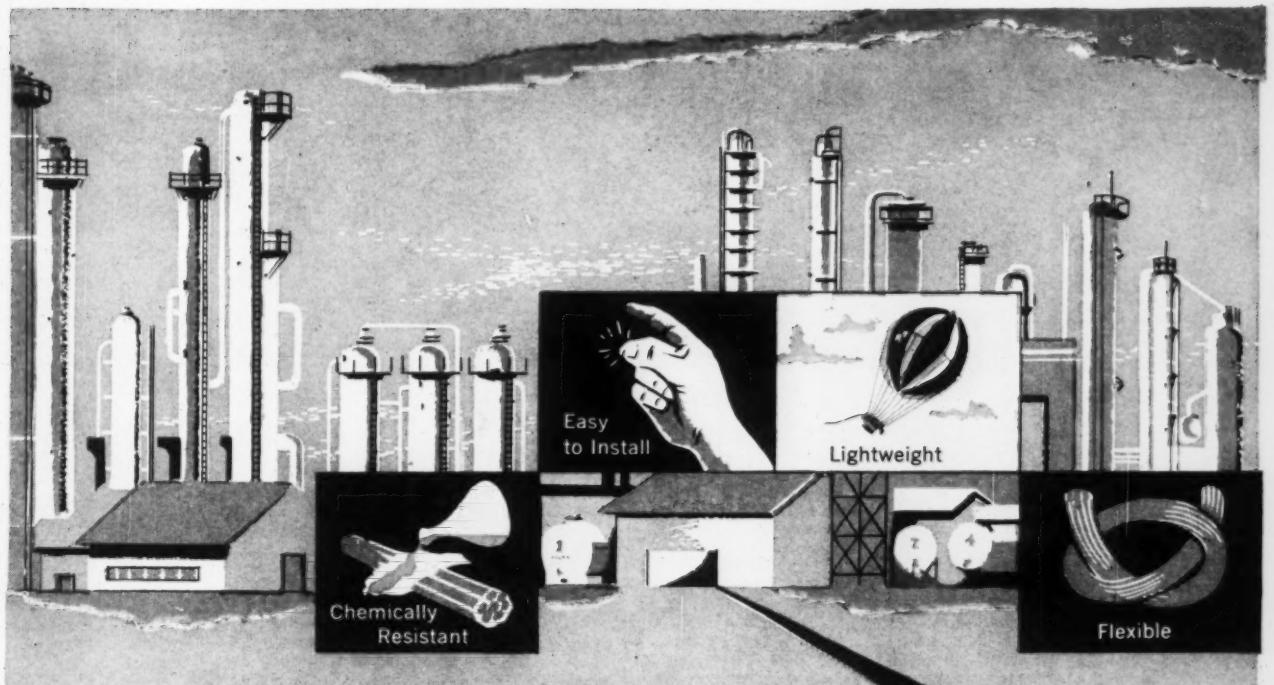
REGULATORS AND CONTROLLERS

LESLIE CO., 299 GRANT AVENUE, LYNDHURST, NEW JERSEY

3573

CONTROLLED QUALITY MEANS QUALITY CONTROLS

For more information circle **36** on inquiry card.



DEKORON

Poly-Cor

harness

Now you can whip high instrument tubing installation and replacement costs in your plant—with Dekoron Poly-Cor®. That's because the chemical resistance of plastic even outlasts expensive alloy tubing . . . because its lighter weight and flexibility make it a snap to install without special tools . . . because you can install practically any number of tubes at one handling, just like electric wiring. You can't lose with Dekoron Poly-Cor — it cuts your investment because of its lower installed cost, cuts your maintenance because it lasts years longer.

Tube up with DEKORON completely

Dekoron products now include single and multiple line metal tubing with plastic coating, multiple tube all-plastic instrument line harness (above), flat 10-tube "ribbon," fittings and junction boxes.

Dekoron® products

QUALITY • RESEARCH • SERVICE

SAMUEL MOORE & COMPANY

DEKORON PRODUCTS DIVISION • MANTUA, OHIO

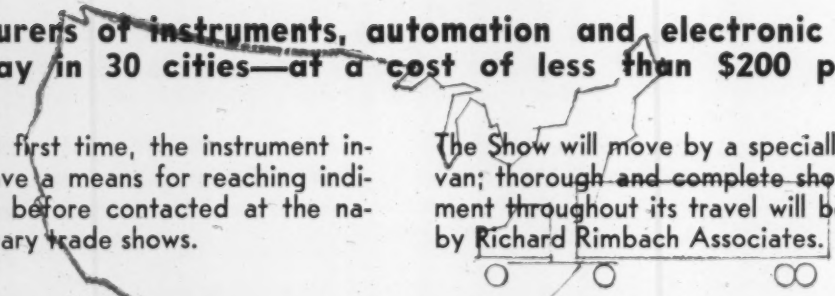
AA-1487

the INSTRUMENTS *and* ELECTRONICS traveling show

Manufacturers of instruments, automation and electronic devices can display in 30 cities—at a cost of less than $200 per city!

Now, for the first time, the instrument industry will have a means for reaching individuals never before contacted at the national, stationary trade shows.

The Show will move by a specially designed van; thorough and complete show management throughout its travel will be furnished by Richard Rimbach Associates.



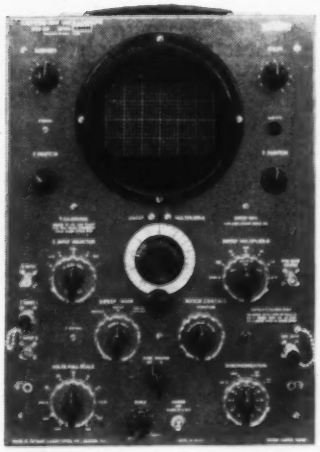
Physical requirements will limit participation to 45 exhibit booths. Your prompt reply will guarantee inclusion in The 1956 Instruments and Electronics Traveling Show.

OVER 30 CITIES COAST TO COAST WILL BE ON THE ITINERARY

Write to Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, Pa., or telephone FAirfax 1-9831

For more information circle **38** on inquiry card.

IBM selects DU MONT TYPE 329* as test oscillograph for their new type 702 computer



When IBM Corporation, world's largest manufacturer of computer equipment, produced their new Model 702, an essential phase of the project involved selection of a cathode-ray oscillograph to go into the field with each computer as standard test equipment. Requirements were strict.

IBM's approach to the problem was to conduct side-by-side evaluation with other competitive instruments. On the basis of actual performance, they selected the Du Mont Type 329 as their test oscillograph.

What are some of the primary reasons why IBM decided on the Du Mont Type 329? Excellent sensitivity—either d.c. or a.c. coupled. Precisely calibrated sweeps with movable notch magnification—ideal for making accurate measurements. Brightness—adequate for display of very fast pulses. Synchronization simplicity—the Type 329 "locks in" on almost any type of signal. Stability—the trace remains steady as a rock despite power line fluctuations, etc. Reliability in service—calibration adjustment requires no extra test gear and is a simple one-step process. And virtually any tube may be replaced without special selection.

Another factor contributing to the selection of the Type 329 was the well known Du Mont Field Service Organization, which assures that regardless of where in the United States the equipment is used, swift, competent service facilities are in the immediate vicinity.

If you have instrumentation requirements, Du Mont facilities are always available for discussion and recommendations. Write us today for complete information on the Type 329, or on any problem you may have relating to cathode-ray instrumentation.

*"Modified slightly for IBM's application."

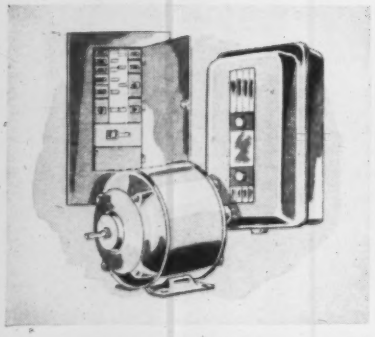
DU MONT

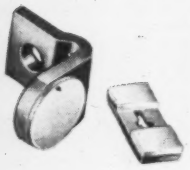
ALLEN B. DU MONT LABORATORIES, INC. • TECHNICAL SALES DEPARTMENT

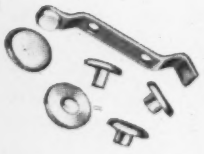
760 Bloomfield Avenue, Clifton, New Jersey

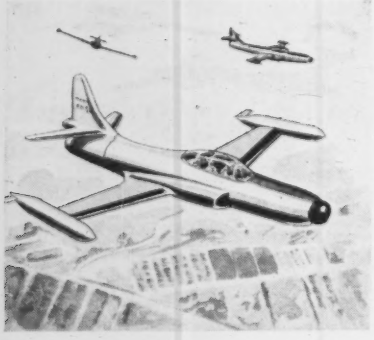
For more information circle **39** on inquiry card.

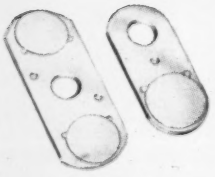
How do your contacts measure up to their jobs?











Are they under-designed... or over-designed?

To be *right* for your needs, contact materials and contact designs must be evaluated in terms of *all* characteristics of the job they are expected to perform. Current and voltage in the interrupted circuit . . . nature of the electrical load . . . number and frequency of operations . . . contact gap and pressure . . . ambient temperature and atmosphere . . . and many other factors must be thoroughly considered, if contacts are to match both the performance and cost requirements of the application.

By consulting with Mallory engineers, particularly during the engineering and design stages of a contact application, you will add to your own facilities the full scope of Mallory's specialized experience in contact research and manufacturing.

- **The wide selection of materials** developed by Mallory metallurgical research encompasses practically every kind of contact service condition.
- **Standard designs** can often be recommended for standard application conditions . . . at sizable savings to you.
- **Special designs** are engineered by a staff which has the knowledge gained during thirty years of contact development.
- **Economical fabrication** of contacts and complete contact assemblies, in Mallory's manufacturing department, can save you money and simplify your own production.

For a consultation on your own contact problems, or for a copy of the Mallory Contact Cataleg, write or call Mallory today.

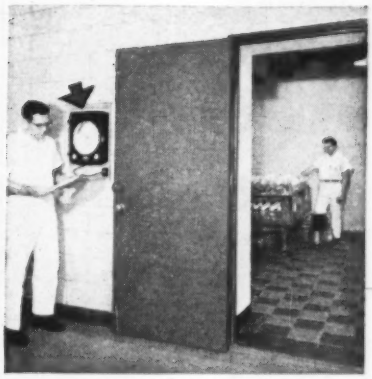
Expect more... Get more from

In Canada, made and sold by Johnson Matthey & Mallory, Ltd., 110 Industry Street, Toronto 15, Ontario.

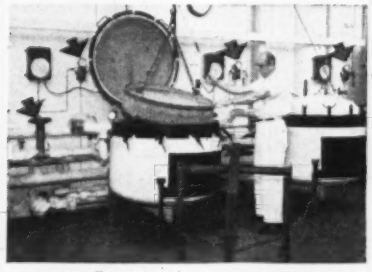
Serving Industry with These Products:
Electromechanical—Resistors • Switches • Television Tuners • Vibrators
Electrochemical—Capacitors • Rectifiers • Mercury Batteries
Metallurgical—Contacts • Special Metals and Ceramics • Welding Materials

P. R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

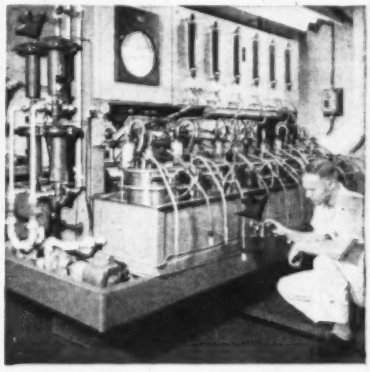
For more information circle **40** on inquiry card.



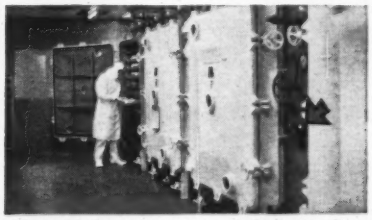
Shaker room and incubator in Fermentation Department. Powers Temperature Recording Controllers are used here.



Ampoule Sterilizers regulated by Powers No. 252 Pressure Regulators and Valves.

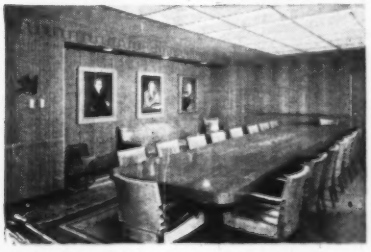


Fermentation process in research pilot plant controlled by Powers ACCRITEM Regulators and FLOWRITE Valves.



A few of the many vacuum dryers equipped with Powers Temperature Controllers.

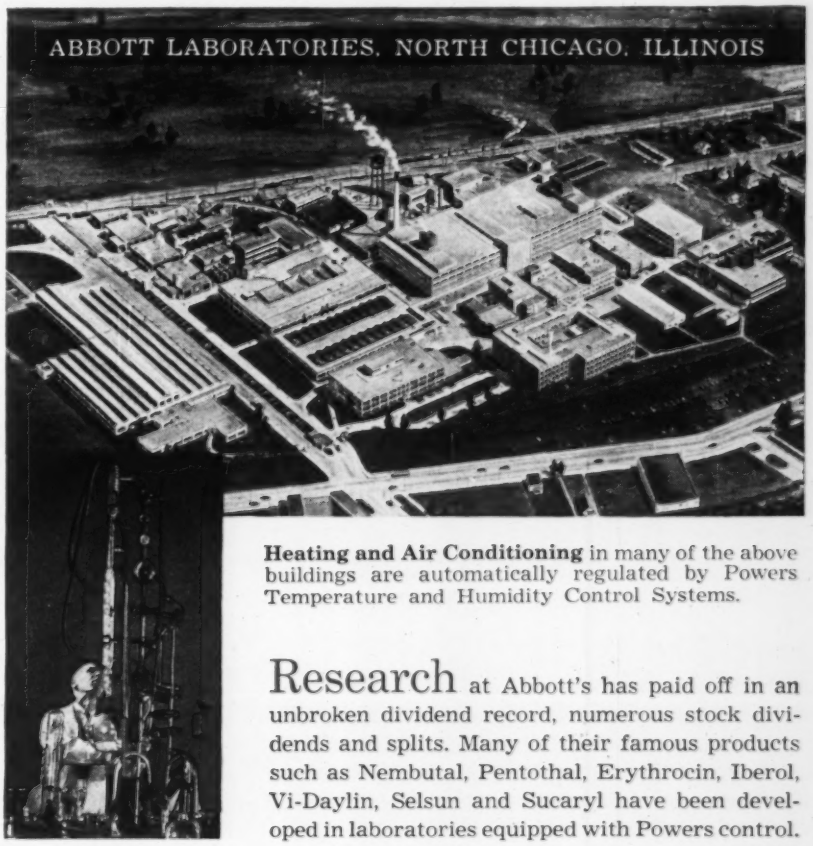
Below: Air Conditioned Room for Board of Directors and executive conferences.



POWERS

AUTOMATIC temperature, humidity and pressure control

.... helps Abbott Laboratories bring better health to millions



Heating and Air Conditioning in many of the above buildings are automatically regulated by Powers Temperature and Humidity Control Systems.

Research at Abbott's has paid off in an unbroken dividend record, numerous stock dividends and splits. Many of their famous products such as Nembutal, Pentothal, Erythrocin, Iberol, Vi-Daylin, Selsun and Sucaryl have been developed in laboratories equipped with Powers control.

Versatility of Powers control used at Abbott's is indicated by some of the applications shown here and in the following installations: Air conditioning control systems for auditorium with 900 seating capacity, executive offices and dining room, cafeteria and animal rooms; also controls for tablet machines, demineralized water heaters, autoclaves and many other applications.

When you need automatic control for temperature, humidity or pressure, call your nearest Powers office or write us direct. An experienced Powers engineer will gladly help you select the right type of control for your requirements.

(c42a)

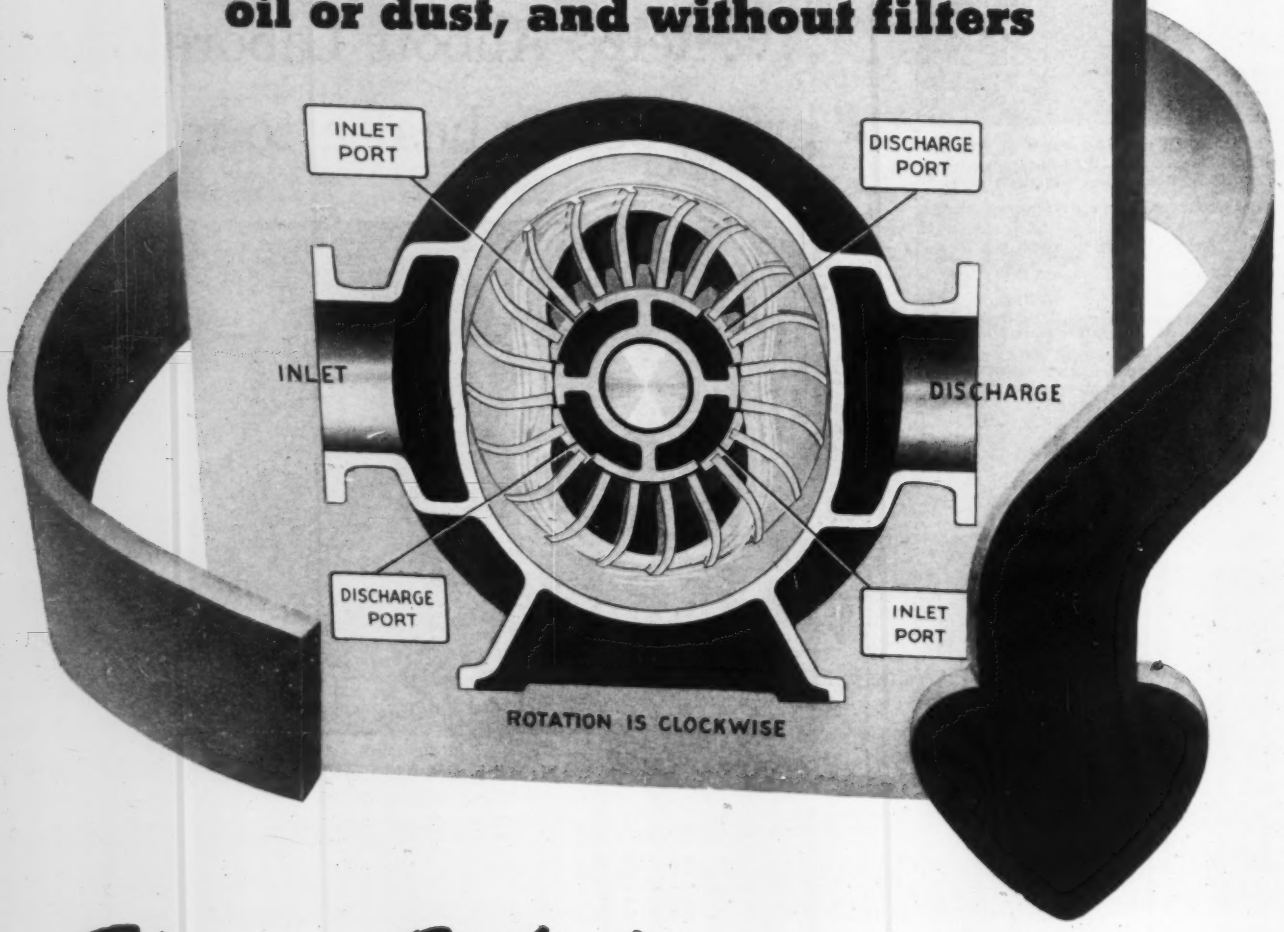
THE POWERS REGULATOR COMPANY

SKOKIE, ILLINOIS | *Offices in chief cities in U.S.A., Canada and Mexico*

Over 60 years of Automatic Temperature and Humidity Control

For more information circle **30** on inquiry card.

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters



Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

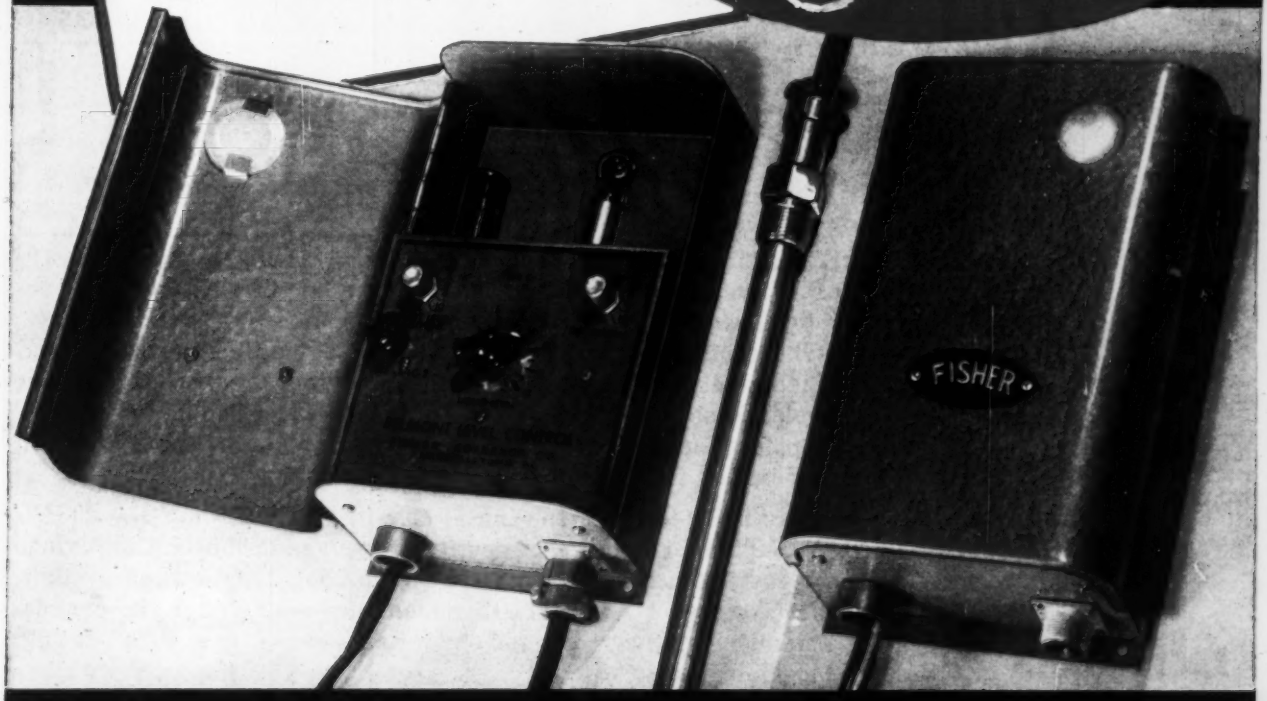
No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY

370 WILSON, SO. NORWALK, CONN.

NOW!

Electronic LIQUID LEVEL CONTROL by FISHER®



Fisher Governor Company widens its scope of liquid level measurement and control with the Fisher "Belmont Series" of capacitance type electronic liquid level controllers.

The "Belmont" can be used on most non-adhesive liquids—chemicals, oil, water, refrigerants, liquefied gases. Operating temperature ranges of the sensing elements are from 500° F. to -425° F. Operating pressure range is vacuum to 50,000 psi or higher.

Only two simple adjustments for liquid and differential control.

Fisher Governor Company has purchased the Thermo Instruments Company, Belmont, California, which has manufactured and marketed the "Belmont" liquid level control the past ten years.

Write for Bulletin F-100

FISHER GOVERNOR COMPANY • Marshalltown, Iowa

WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

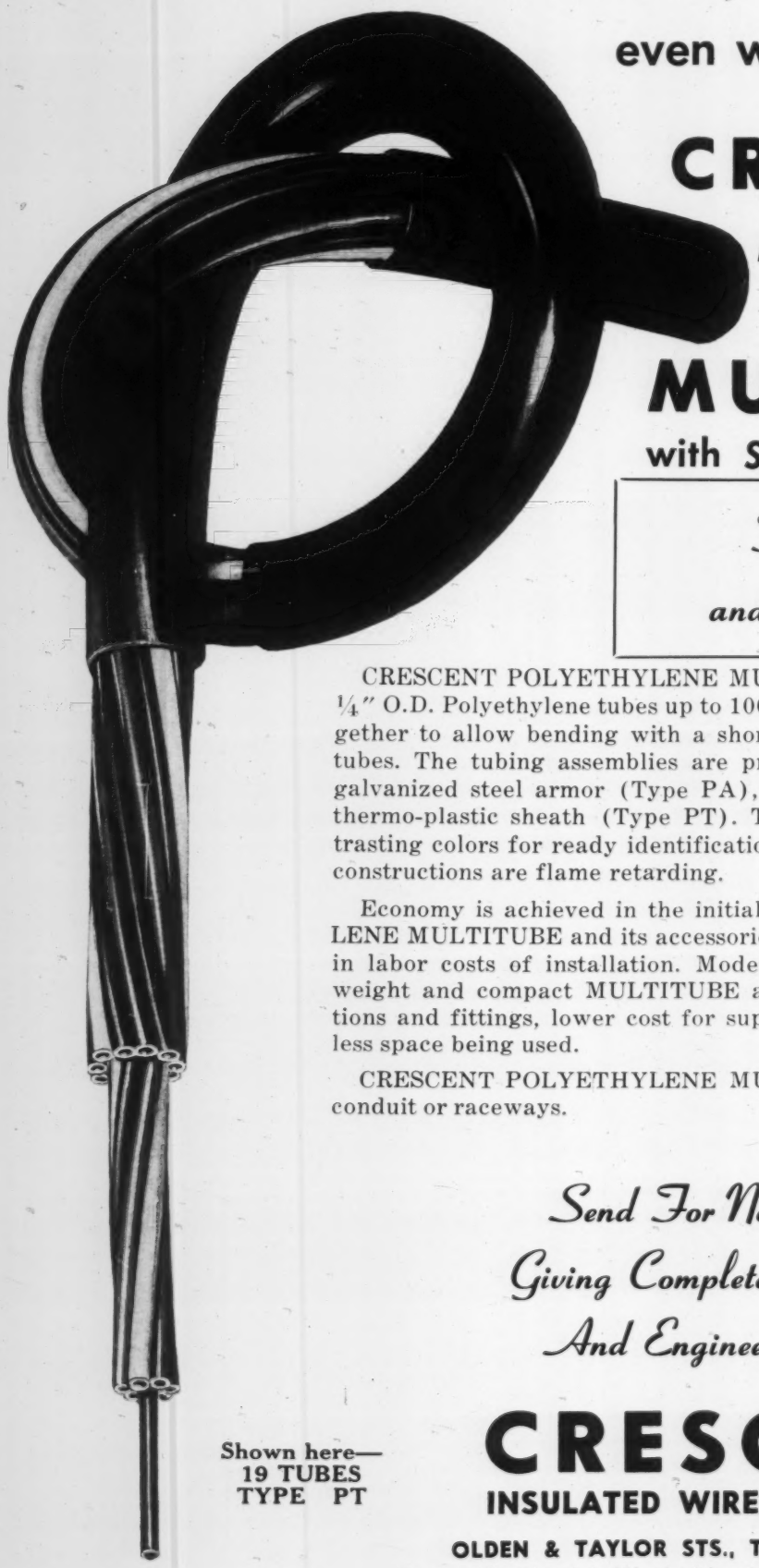
FISHER

Our 75th ANNIVERSARY

For more information circle **42** on inquiry card.

There is No Distortion of the Tubes.....

even when tied in a knot



CRESCENT

POLYETHYLENE

MULTITUBE

with *Spirally Cabled* Tubes

For Instrument and Control Tubing

CRESCENT POLYETHYLENE MULTITUBE is composed of 2 to 19, ¼" O.D. Polyethylene tubes up to 1000 feet in length, spirally cabled together to allow bending with a short radius without distortion of the tubes. The tubing assemblies are protected by a flexible interlocked galvanized steel armor (Type PA), or by a tough corrosion-resistant thermo-plastic sheath (Type PT). Tubes are furnished in seven contrasting colors for ready identification of each tube at both ends. Both constructions are flame retarding.

Economy is achieved in the initial cost of CRESCENT POLYETHYLENE MULTITUBE and its accessories, as well as in substantial savings in labor costs of installation. Moderate to long length runs of light weight and compact MULTITUBE assemblies result in fewer connections and fittings, lower cost for supports or racks, ease of mounting, less space being used.

CRESCENT POLYETHYLENE MULTITUBE can be pulled through conduit or raceways.

Send For New Bulletin
Giving Complete Information
And Engineering Data

Shown here—
19 TUBES
TYPE PT

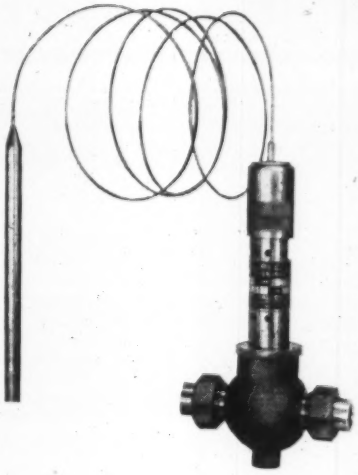
CRESCENT

INSULATED WIRE & CABLE CO.

OLDEN & TAYLOR STS., TRENTON, NEW JERSEY

For more information circle **43** on inquiry card.

CUT STEAM WASTE 2 WAYS with Klipfel THERMOSTATIC VALVES



Klipfel No. 1449
Temperature Control Valve

Control that's accurate plus positive tight closing make Klipfel Thermostatic Valves real steam savers in operation.

Vapor pressure operated, these tank thermostats give control that's dependably sure . . . always.

Two types of single seated inner valves—both successfully proved on Klipfel's pressure reducing valves—are available for permanent tight closing.

Stainless steel ball inner valve and seat bushing with integral guides stops steam leakage, prevents wasteful, damaging overheating.

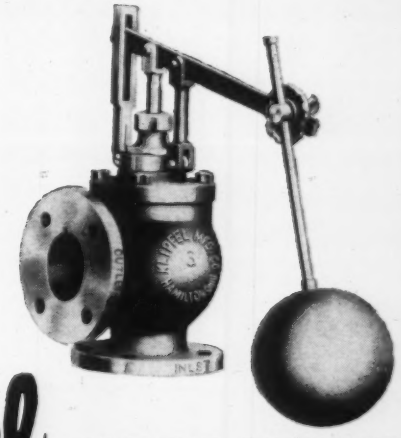
For high pressure applications and in larger sizes, Klipfel's pilot balanced, cup disc type inner valve gives the same advantage of dead end closing.

For complete details, write Dept. C-9 for Bulletin 354.

Float Valves, Reducing Valves, Tank Thermostats, Back Pressure Valves.

Klipfel
Valves, Inc.
HAMILTON, OHIO

TO KEEP LIQUIDS ON-THE-LEVEL



Klipfel **FLOAT VALVES**

- For liquid level control that's really automatic, depend on Klipfel Float Valves. They have a forty year record of dependability in thousands of installations, large and small, water and chemical.
- Available indirect acting or pilot control types, either single seated or double seated. Whatever your requirements of pressure, temperature, fluid and closure, there is a Klipfel Float Valve for the job.
- Also available with Klipfel's exclusive cup disc inner valve for tight control for liquids injurious to rubber and leather, and for higher pressures.

- For complete details, write Dept. C-9 for Bulletin 254. Float Valves, Reducing Valves, Tank Thermostats, Back Pressure Valves.

Klipfel **Valves, Inc.**
DIVISION OF HAMILTON-THOMAS CORP
HAMILTON, OHIO
EXPORT DEPT. 1010 SCHAFF BLDG.
PHILADELPHIA, PA.

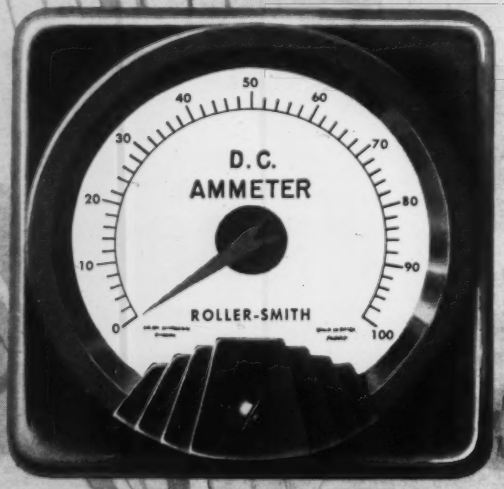
For more information circle **44** on inquiry card.

"See"-ability Unlimited...

with the

ROLLER-SMITH 250°

SWITCHBOARD METER



With the introduction of its 250° Arc-Angle Switchboard Meters, Roller-Smith's Master Instrument Makers have achieved the ultimate in compactness of design and ease of reading for panel indicating instruments. These new meters, entirely redesigned from the inside out, contain a completely new, ultra modern movement and feature an exceptionally long scale—2½ times greater than conventional instruments. Styling . . . by a leading industrial designer . . . has given them the attractive "new look" of the entire Roller-Smith line.

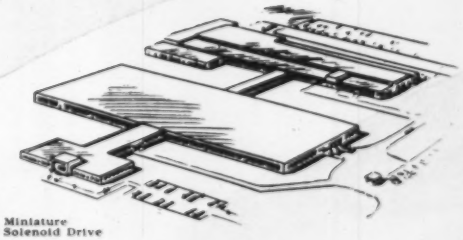
The superb craftsmanship and top quality materials that go into the Roller-Smith 250° Arc-Angle Meter are characteristic of all the electrical indicating instruments in our complete line.

For assistance in arriving at economical, workable solutions to your instrument problems, consult our staff of experts.

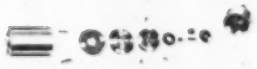
ROLLER-SMITH
Instrument Division
CORPORATION
1825 WEST MARKET STREET BETHLEHEM, PENNSYLVANIA
Precision Products Since 1900

For more information circle 45 on inquiry card.

Sub-miniature Assemblies To Gigantic Electronic Systems . . . . . .

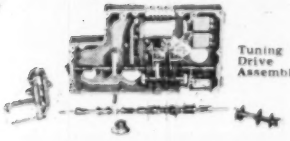


Miniature Solenoid Drive



Miniature Gear Reduction Unit

Sub-miniature Circuits —Transistorized Application



Tuning Drive Assembly

DAYSTROM INSTRUMENT has produced tiny precision assemblies . . . to gigantic gun directors and fire control systems — all within their modern 350,000 sq. ft. plant. When you combine Daystrom's team of skilled engineers with efficient production methods and modern facilities, you'll understand how Daystrom has been able to achieve mass production of such products—on time and at low cost—for every branch of the Armed Forces and industry.

. . . For the NAVY

Radar Fire Control Systems, Mine Detecting Devices, Anti-Submarine Attack Directors, Catapult Speed Indicators, Servo Control Systems, Torpedo Assemblies.

. . . For the AIR FORCE

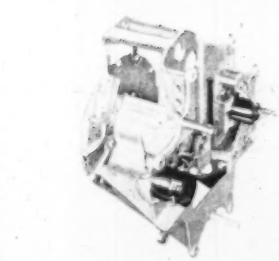
Capacitance Testers, All-Altitude Servo Indicators, Transistorized Receivers, R F Switches, Potentiometers.

. . . For the ARMY

Mechanical Fire Control Systems, Fuzes, Communication Systems and other instrumentation for all branches of the Army.

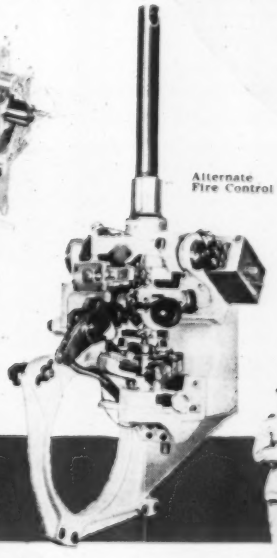
. . . For INDUSTRY

Test Equipment, Computing Devices, Radar Equipment, Nuclear Equipment, Gyro Mechanisms, Electronic and Electro-Mechanical Devices.

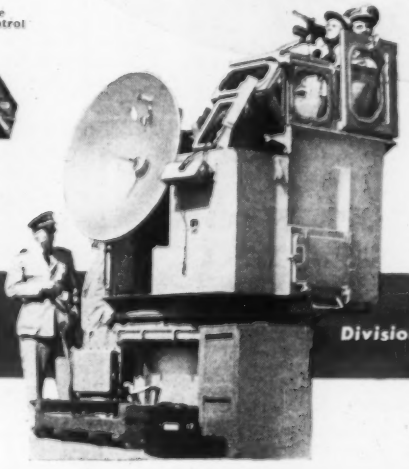


Dummy Director Assembly

Antenna Drive Housing



Alternate Fire Control



Mark 36 Director

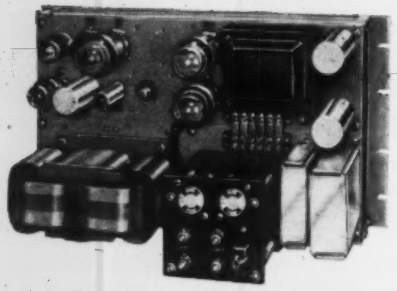
DAYSTROM INSTRUMENT

Division of Daystrom, Inc.

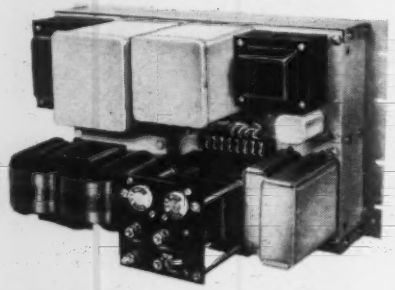
ARCHBALD, PENNA.

Write For Our Facilities Report

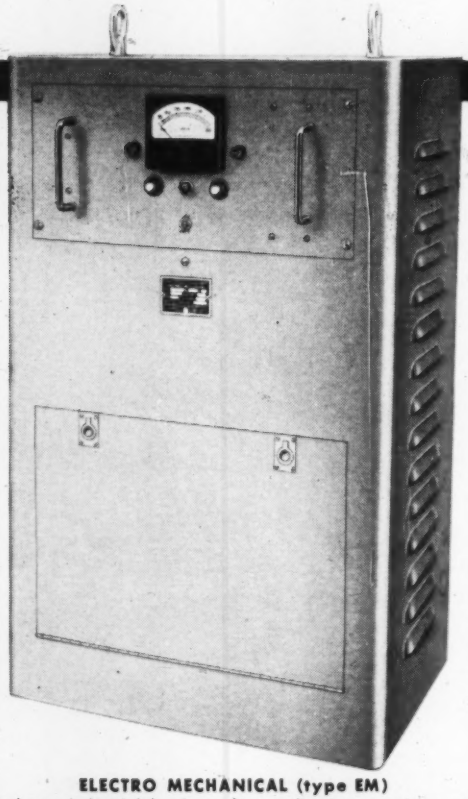
For more information circle **46** on inquiry card.



INSTANTANEOUS ELECTRONIC (type IE)
For instantaneous correction and extremely close control. Completely electronic. No moving parts.



TUBELESS MAGNETIC (type TM)
For unattended locations and critical uses where tube failure cannot be tolerated.



ELECTRO MECHANICAL (type EM)
For large industrial loads or for applications requiring zero waveform distortion and high efficiency.

STABILINE AUTOMATIC VOLTAGE REGULATORS

Designed to Maintain Root Mean Square Voltage

Here is a complete line of automatic voltage regulators designed with the application in mind . . . with *operating* characteristics that *always* equal or better the nameplate rating.

Of special importance is the fact that STABILINE maintains the root mean square voltage — the voltage rating for which all electrical equipment is designed. Before you purchase automatic voltage regulation equipment, make sure it is R.M.S. responsive.

We have detailed information about STABILINE automatic voltage regulators. Send the coupon for your copy of our Bulletin S351.

Be sure to see Superior Electric's Mobile Display when it is in your area.

THE SUPERIOR ELECTRIC COMPANY

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REPRESENTATIVES
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THE SUPERIOR ELECTRIC COMPANY
709 Reynolds Avenue, Bristol, Conn.

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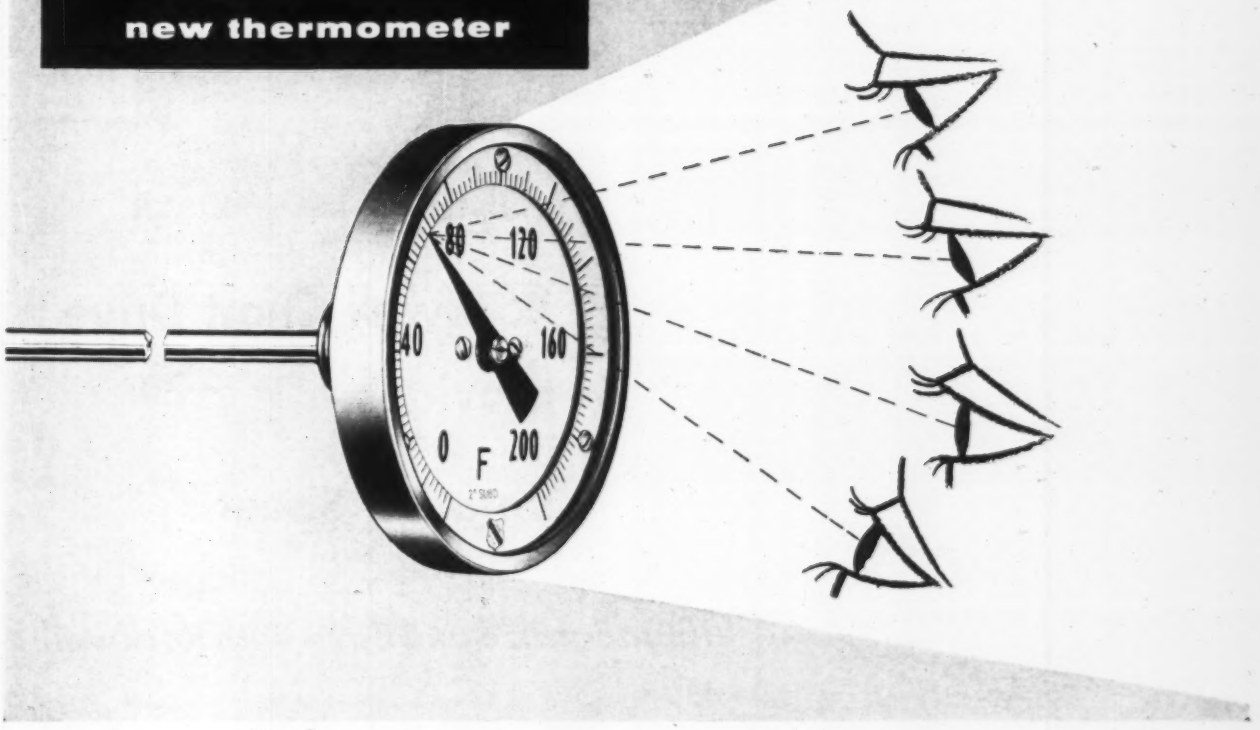
City ..... *Zone* ... *State* .....

For more information circle **41** on inquiry card.

ANTI-PARALLAX MAXIVISION is yours in this new thermometer



Now you can read temperatures *right at the process* with the same ease, accuracy and economy as pressure readings. The Anti-Parallax Maxivision Dial on this new all stainless steel American Bi-Metal Thermometer assures these important advantages. The large, easy-to-read black figures and graduations are carried on a raised ring set close to the glass, with pointer at the same level. Parallax error is practically eliminated.

With this new thermometer in service, field operators can eliminate frequent trips to the control house to observe process changes. Indoors or outdoors, this fine, all stainless steel American instrument is truly climate-proof. Because the case is only 3" in diameter, the thermometer fits where space is limited. Ample clearance behind the case makes installation easy and fast with a small wrench. Read the specification highlights, then get full details about this new high-accuracy American Bi-Metal Thermometer.

PHONE your Industrial Supply Distributor for prompt attention to your needs. He is always ready to help keep your production going by making fast delivery from local stocks.

SPECIFICATIONS

New AMERICAN ALL-STAINLESS STEEL BI-METAL THERMOMETER with ANTI-PARALLAX MAXIVISION DIAL

Dial: Exclusive anti-parallax Maxivision dial, with scale approximately 6" long. Pointer set at same level as scale.

Climate-Proof Case: All stainless steel. 3" diameter. Threaded bezel. Selected clear, extra-heavy cover glass. Heat-resistant gaskets between glass and case seal the thermometer against rain, frost, sand, dust, fumes—climate-proof.

Temperature Ranges: From minus 80° to plus 1000° F. Accuracy within 1% of range.

Low-Mass Bi-Metal Coil: Welded to stem plug. Accurately centered in stem. Non-freezing, non-corrosive silicone fluid on coil dampens vibration, accelerates heat transfer, speeds response; does not gum, resists capillary action.

Pointer: Index type. Easily accessible from front of dial for positive adjustment over entire range. Pointer shaft guided by friction-free bearings.

Stem: 18-8 stainless steel, mirror polished. All joints welded. Resists corrosion. Provides strong, rigid and tight closure against process pressures. Lengths: 2½" to 24".

Connection: Fixed, ½" N. P. T.

Separable Sockets: Available for use in closed systems or where measured medium is corrosive to the stainless steel stem. Fit over all standard stem lengths except 2½".

AMERICAN INDUSTRIAL INSTRUMENTS

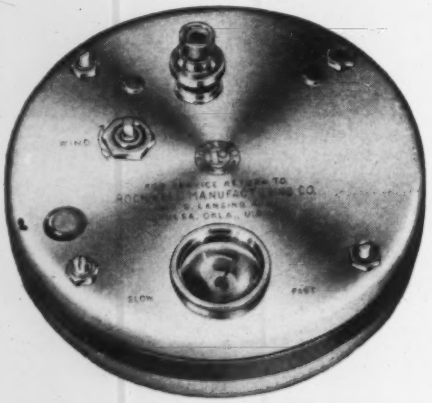
A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

MAKERS OF 'ASHCROFT' GAUGES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, *Stratford, Conn.* HANCOCK VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Oklahoma.* AIRCRAFT CONTROL PRODUCTS, *Danbury & Stratford, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*

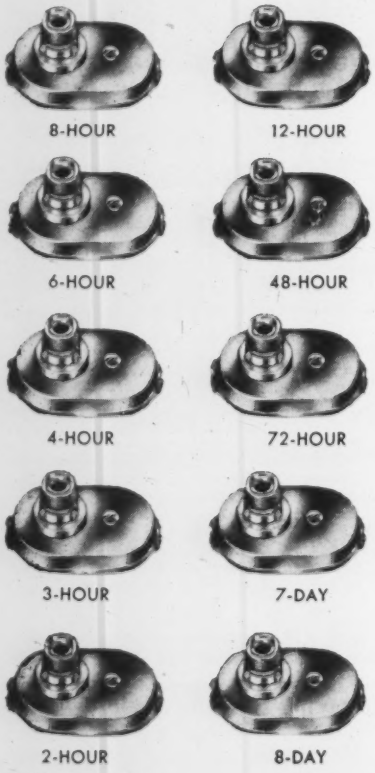
For more information circle **47** on inquiry card.

For All Your Meters, Instruments, Recorders . . .

ROCKWELL CHART DRIVE WITH TURRETS FOR THE ELEVEN SPEEDS



Basic Drive with 24-Hour Hub



1 Rockwell Chart Drive provides 11 Rotation Speeds

Standardize and Save with Rockwell

FITS PRACTICALLY ALL INSTRUMENTS

In designing the Rockwell Chart Drive, dimensions were deliberately established so that the drive can be adapted to fit practically all instruments. Simple adaptors are available to correctly locate it both as to position and height.

REDUCE CHART DRIVE INVENTORY

By standardizing on Rockwell drives, the usual inventory of spare drives of various makes and speeds can be greatly reduced. Maintenance work is simplified and a shortage of drives for any specific application is eliminated.

Write for bulletin 1079

YOU CAN RELY ROCKWELL ON ROCKWELL

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INSTRUMENT DIVISION • BOX 2396, TULSA, OKLA.

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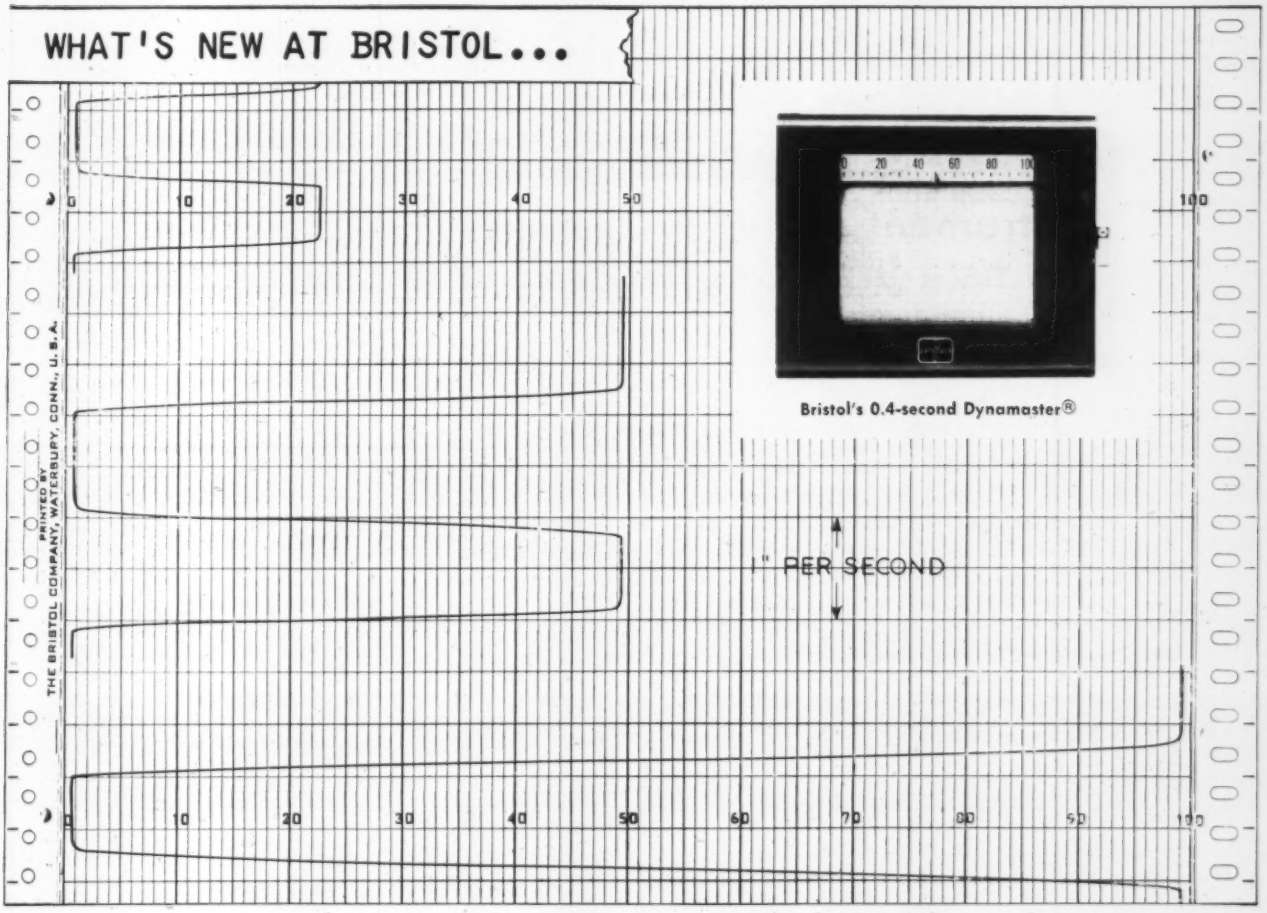
Pittsburgh San Francisco Seattle Shreveport, La. Tulsa

For more information circle **48** on inquiry card.



ACTUAL CHART RECORD (less than ½ size) shows step-function responses for various magnitudes. Chart speed: 2 divisions (1 inch) per second.

New Bristol High-speed Dynamaster® Recorder

crosses 11-inch chart in 0.4 second

Bristol's new 0.4-second Dynamaster is the fastest self-balancing recorder on the market! And with no overshoot!

This high-speed instrument sets new standards for recorders in the fields of rocket and jet-engine testing, wind tunnel measurements, automatic-machine-tool control, scientific laboratory testing and numerous industrial applications.

What's more, no sacrifices have been made in the usual Bristol high standards in building this high-speed instrument. The accuracy, sensitivity, minimum range, reproducibility, dynamic characteristics and reliability of this new model are the same as for slower-speed Dynamasters. The instrument is equipped with a control to adjust the damping characteristics.

Write for complete data on this instrument today. The Bristol Company, 113 Bristol Road, Waterbury 20, Conn.

5.37

SPECIFICATIONS

SPEED
0.4-second to within 0.25% of balance for full-scale step-response without overshoot.

SENSITIVITY
Dead band less than 0.1% of full scale.

RANGES
Minimum range of 1 millivolt d-c.

CHART
12¼ inches, 11 inches calibrated.

CHART SPEEDS
Up to 4 inches per second.

TRADE MARK BRISTOL'S REG. U.S. PAT. OFFICE

BRISTOL

POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **49** on inquiry card.

L&N Precision Stabilized Power Supplies guard instrument accuracy against line voltage fluctuations

• Leeds & Northrup has developed two types of power supplies to meet the precision requirements of our own instruments such as the Recording Spectrometer, the Electro-Chemograph® and the Infrared Gas Analyzer. These power supplies have been so successful that we are now making them available for general use.

For Multiplier Phototubes and Similar High Voltage Applications

Two Independent Output Voltage Sources — Ranges
(1) 500 to 1310 volts d-c across 1 megohm load. Continuously adjustable with coarse and fine dials. *(1; see fig.)*
(2) 480 to 790 volts d-c across 1 megohm load. Continuously adjustable with 12-position coarse dial only. *(2; see fig.)*

Line Voltage Tolerance — 0.01% d-c output change for a change in a-c line voltage from 100 to 125 volts.

Drift—Not more than 0.01% for a period of 8 hours or more, after a 20-minute warmup.

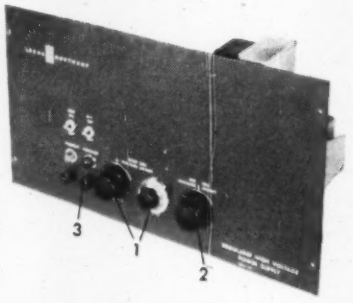
Ripple—Considerably less than 30 millivolts rms.

Time Delay Relay Circuit—30 second time delay allows tube heaters to come to proper operating temperature before high voltage is applied. *(3; see fig.)*

Size—19″ x 10½″ x 10″, for relay rack mounting.

Catalog Number—101038

Price—$715.00 F.O.B. Phila.; subject to change without notice.



For General Purpose Laboratory Applications

Output Voltage Range—105 to 125 volts d-c, continuously adjustable.

Current Range—0–200 ma at 105 volts.

Stability—0.05% d-c output change for a change in a-c line voltage from 105 to 125 volts.

Drift—No greater than 0.05% in 24 hours.

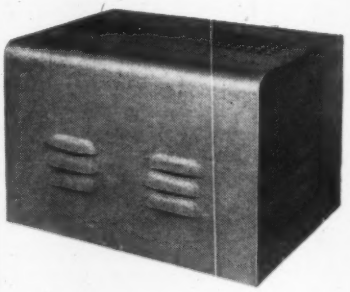
Load Current Regulation—At 105 volts output, load change from 0 to 200 ma produces a 0.05% change in output voltage.

Ripple—Less than 5 millivolts rms.

Size—9 1/16″ x 13 5/16″ x 9 7/8″, with metal case.

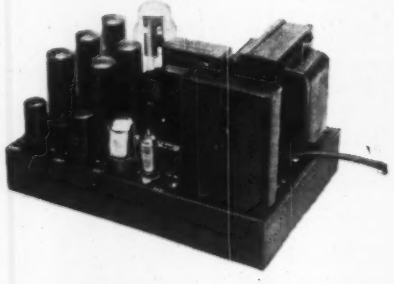
Catalog Number—101-2-0-2

Price—$276.00 F.O.B. Phila., subject to change without notice.



Catalog Number—101-2-0-1, same as above except includes chassis only without metal case and has a constant voltage output of 105 volts.

Price—$203.00 F.O.B. Phila., subject to change without notice.



Order through our nearest district office, or directly from . . .,

LEEDS & NORTHRUP COMPANY
4955 Stenton Ave., Phila. 44, Pa.

For more information circle **50** on inquiry card.

Editorial...

INSTRUMENTS and AUTOMATION

Automation Links the Office, Plant and Factory

PERHAPS the greatest contribution resulting from the coining of the new word automation has been the awakening of interest in control devices on the part of executive directors of offices, plants, and factories. Whereas the field of instrumentation had already evolved into a cohesive and vast field of endeavor in the processing industries, the majority of office and factory managements had remained relatively unimpressed with the power of automatic control of data and variables—until automation appeared as a new word.

This fact was vividly emphasized by the makeup and attendance of the First Automation Exposition (held in New York in 1954), which was unique in that it attracted the leading personalities in finance, labor, and education—as well as those of offices, plants, and factories. This broad appeal is again evident in the makeup of the Second Automation Exposition, to be held Nov. 14-17, 1955, Chicago Navy Pier. Only in a trade show dedicated to automation could there be both a Conveyor Clinic and a Computer Clinic, both plant automation and office automation.

OFFICE automation, in particular, is expanding at a rate that is itself expanding. The University College, University of Chicago, is conducting an Office Automation Conference for Senior Officers, Shoreland Hotel, Chicago, Nov. 14-15, which is expected to attract top executives of industry and finance. The conference management is arranging means for these men to attend the Automation Exposition—and also to participate in the Computer Clinic at the Automation Exposition where the equipments of Austin, Bendix, Clevite-Brush, IBM, Librascope, and Teleregister (with office-automation implications) as well as Berkeley Div., Beckman, Electronic Associates, and Goodyear will be demonstrated.

ANOTHER unique feature of the Automation Exposition is the Conveyor Clinic, featuring equipments of the Chainveyor Corporation, Mechanical Handling Systems, Inc., and Jervis B. Webb Company. Conveyors will thus be dramatized as an important part of factory automation. All of which is mentioned to illustrate the manner in which "automation" is forging a link between the offices, plants, and factories of America. The theme of the Automation Exposition—"The Show of the Future"—seems entirely appropriate and well on its way to realization.

Fred D. Marton Joins I & A Staff

WITH this issue, Fred D. Marton joins the staff of *Instruments and Automation* as Managing Editor. Fred has an impressive record as an instrument man, particularly in the wet processing field, and all readers of *Instruments and Automation* can look forward to many new and exciting features designed to keep them completely informed on all aspects of modern process instrumentation.

Fred D. Marton

Fred comes to us from Rust Engineering Co., where as Instrument Engineer he worked on instrumentation projects for Alcoa, Hollingsworth & Whitney, Crosset Paper Mill, Pan-American Refining, Hammermill Paper Co., Monsanto Chemical, etc. Previous to his position with Rust he had served with Blaw-Knox, American Viscose Corp., Yale & Towne Mfg. Co., U. S. Gauge, Brown Instrument Div. of Minneapolis-Honeywell Regulator Co., and ACF-Brill Motors.

Born in Austria, Fred received his engineering education at the Technische Hochschule, Graz, Austria, where he was awarded an "Ingenieur" degree and later received a "Diplom-Ingenieur" degree from the Technische Hochschule, Berlin, Germany. Previous to emigrating to this country in 1937, he worked as a design engineer for Austro-Daimler Puch Werke, Graz, Austria, and production supervisor for Gesellschaft fuer Stoffueredlung, M.B.H., Berlin, Germany. His fluency in French, German, Italian, Greek, Hungarian, and Serbo-Croatian will help us keep in touch with all foreign developments.

Fred's professional experience has been fortified by several editorial tasks he performed for the Instrument Society of America. He has edited the *Pittsburgh Headlines* (Pittsburgh Section ISA Publication) and has served as Associate Editor of the *ISA Journal* in charge of "New Products." He is also an associate member of the Associated Editors Society of Pittsburgh.

Fred is in a position to evaluate several important and basic problems in process in instrumentation—What percentage of the plant dollar is going into instrumentation? What trends have been established? What is happening to the instrument department? These questions will be among the first that Fred will work on for the readers of *Instruments and Automation*.

New Instruments...

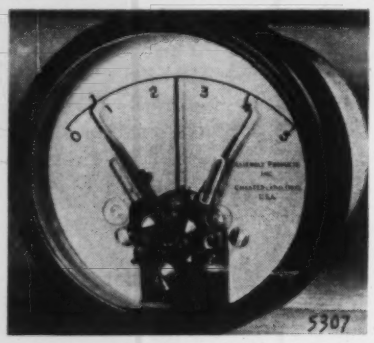
INSTRUMENTS and AUTOMATION

For further information use the postage-free order card on page 1569

PROCESS CONTROL AND MONITORING

Electric-contact-type Automatic Controller

New "Model 255C Ruggedized Meter-Relay" features "trip" (or control) adjustable from front to any

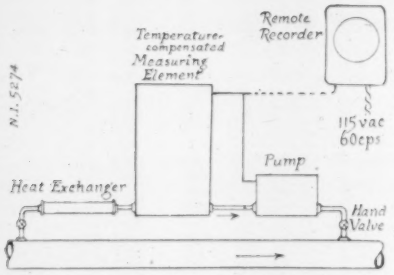


point on scale. High limit, low limit or high-and-low contact arrangements are available. Sensitivity ranges are 0-20 microamp to 0-50 amp, or 0-5 millivolts to 0-500 volts. Higher ranges require external shunts or multipliers. Instrument rectifiers or thermocouples are used for AC or RF. Millivoltmeters with temperature dials have cold junction compensation.—*Assembly Products, Inc., Chesterland, Ohio.*

For more information circle **201** on inquiry card.

Temperature-compensated Continuous Viscosimeter

New temperature-compensated "Viscometer" is particularly suitable for general petroleum applications; provides a continuous record of viscosity; is available for automatic con-

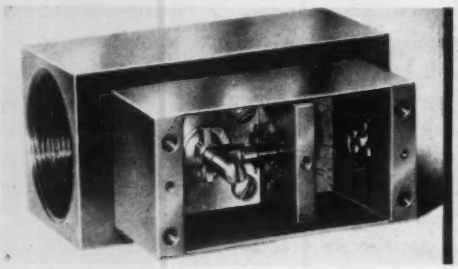


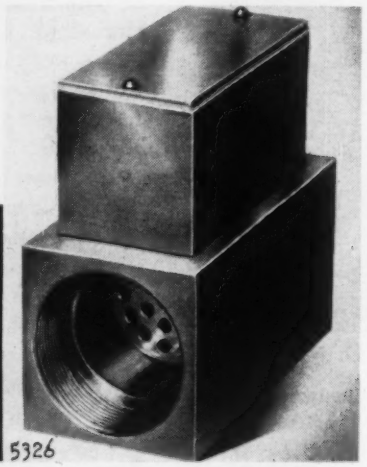
trol. A continuous sample flows to temperature-compensated measuring element. When necessary: (1) heat exchanger to bring sample temperature within compensating range and (2) small proportioning pump to return sample. All electrical components comply with Underwriter's requirements for Class 1 Group D locations. For automatic control, recorder provides 3-15-psi air pressure.—*Norcross Corp., Dept. #N27, Newton 58, Mass.*

For more information circle **202** on inquiry card.

Pulsating-flow Primary Measuring System

New flow-rate metering primary-element assembly for accurate measurement of pulsating fluid flow can be used with all types of fluids, including corrosive liquids, at line pressures up to 2000 psi, for measuring average or instantaneous flow-rates up to 8 gpm in a 1-in ID line. Principle: an orifice plate with sixteen ⅛-in holes is mounted on a hinged support and actuates, through a seal, a force-responsive unbonded-wire strain-gage type pickup. Force-transmitting seal is specially designed



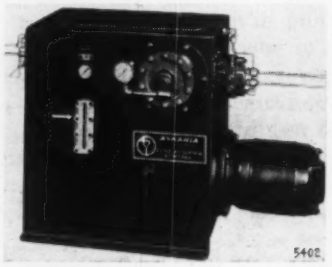


to transmit small drag force to pickup without being affected by variations in line pressure. Because of high natural frequency of orifice-plate force-pickup system (about 2000 cps with a 1-in plate) new unit requires only one steady-state calibration even when various pulsating flow patterns may be encountered; is also balanced to be nonsensitive to axial vibration. ★ Complete flow-rate meter includes also an amplifier-computer unit which performs a square-rooting function and supplies a correct linear signal to user-selected flow-rate indicator (voltmeter, oscillograph, etc.). With a slow indicator, average flow is indicated.—*Dynamic Instrument Co., Inc., 28 Carleton St., Cambridge, Mass.*

For more information circle **203** on inquiry card.

Dual Hydraulic Controller

New "Twin Jet Regulator comprises two complete and independent hydraulic controllers in a single housing, is

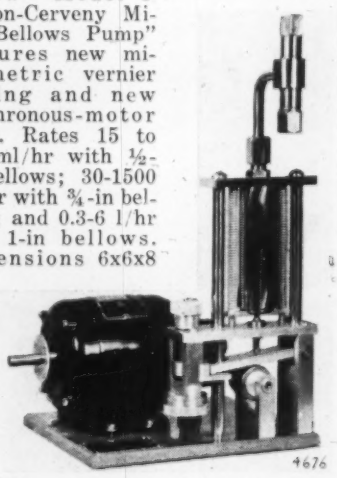


a larger, more powerful version of maker's "Double Jet Regulator," incorporates same jet-pipe control systems but also includes a 1-hp motor and 7-gpm pump.—*Askania Regulator Co., 240 East Ontario Street, Chicago 11, Ill.*

For more information circle **204** on inquiry card.

Metering Pump

New "Model P Corson-Cerveny Micro Bellows Pump" features new micrometric vernier setting and new synchronous-motor drive. Rates 15 to 750 ml/hr with ½-in bellows; 30-1500 ml/hr with ¾-in bellows; and 0.3-6 l/hr with 1-in bellows. Dimensions 6x6x8



in; pipe connections ⅛ in; weight 10.2 lb.—*Research Appliance Co., Box 463, Pittsburgh 9, Penna.*

For more information circle **205** on inquiry card.

Conductivity Cell for Pipe-line Installation

New conductivity cell for measurement of effluent waters is installed in process lines in the same manner as a short length of pipe, utilizes self-cleaning ring electrodes. Thermistor for automatic temperature compensation (optional) is mounted wholly within outside-pipe structure of cell. Choice of materials for housing and electrodes; wide range of cell constants.—*Industrial Instruments, Inc., Cedar Grove, N. J.*

For more information circle **206** on inquiry card.

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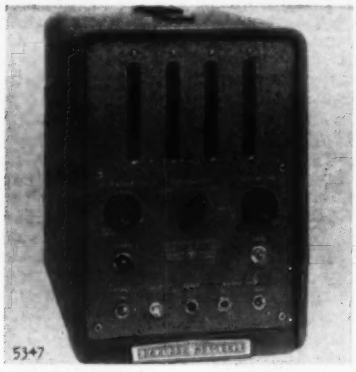
Multi-purpose Digital Indicator

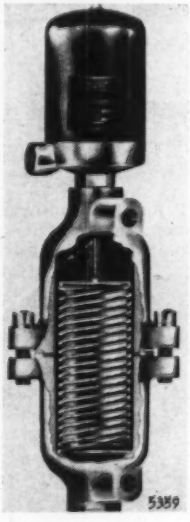
New "Model 521A Industrial Counter" can indicate frequency, speed, rpm, random events, weight, tempera-



ture, pressure, acceleration, etc., in association with suitable pickups or primary measuring elements. It provides direct numerical readings in cps, rpm or rps from 1 cps to 120 kc. Period of count is either 0.1 sec or 1 sec and count display time can be varied at will.—*Hewlett-Packard Co., 275 Page Mill Road, Palo Alto, Calif.*

For more information circle **207** on inquiry card.

High-pressure Process Liquid Level Controller



New liquid-level controller for high-pressure service utilizes buoyancy principle: a solid block displacer (of glazed porcelain or Karbate) "loads" its weight on a compression support spring. Raising liquid level imparts buoyancy to displacer in proportion to weight of liquid it displaces to (first) "unload" spring and (second) upon further rise, to produce desired switch action. Conversely, falling liquid level subtracts buoyancy to cause low-level switch action. "Model A-1501" is designed for pressures up to 1500 psi; "A-3001" up to 3000 psi; "A-5001" 5000 psi. Each can be used for either high- or low-level service. New controller is designed to operate with

NOW-WELCH DUO-SEAL® PUMPS *with* VENTED-EXHAUST

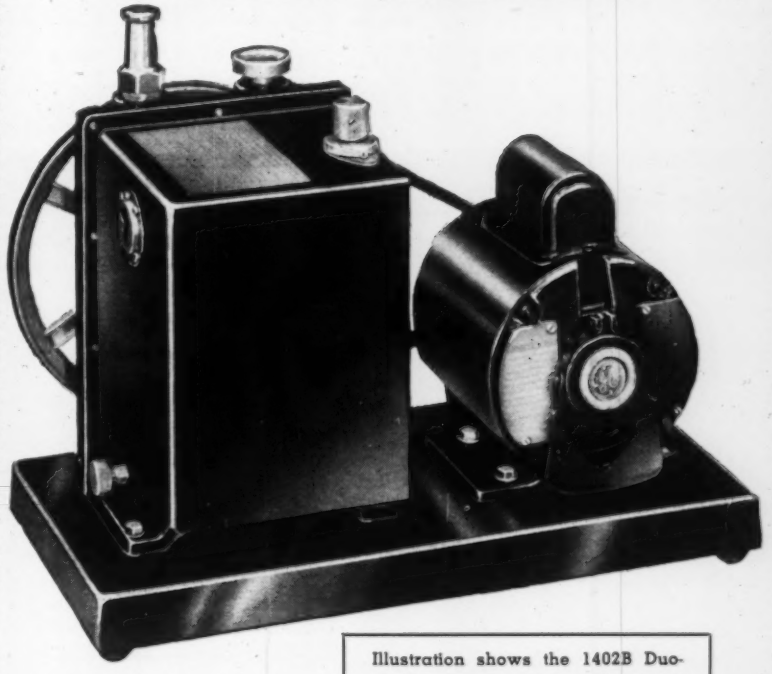


Illustration shows the 1402B Duo-Seal Pump equipped with Vented Exhaust.

★ Vented Exhaust Permits Pumping of Most Condensable Vapors.

★ Eliminates Use of Traps or Oil Separators in Systems Containing Water or Other Condensables.

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For more information circle **51** on inquiry card.

Miniature Pressure Transducers

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MINIMUM RESPONSE TO VIBRATION OR ACCELERATION

TEMPERATURE COMPENSATION OVER 315° F. INTERVAL

20 MILLIVOLTS AT 5 VOLT EXCITATION

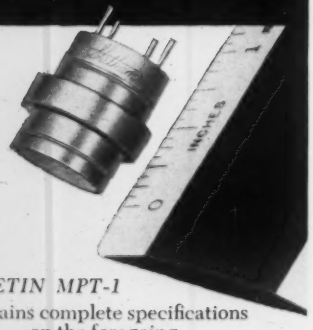
PRESSURE ADAPTERS FOR CLOSED LINE APPLICATIONS

HOMOGENEOUS SENSING DIAPHRAGM SURFACE

NO EPOXY RESIN PRESSURE SEALS

MAXIMUM LINEARITY

ABSOLUTE PRESSURE
0-5 to 0-150 PSIA . . . MODEL P130
DIFFERENTIAL PRESSURE
± 2.5 to ± 25 and 0-5 to 0-150 PSID . . . MODEL P131
GAGE PRESSURE
0-5 to 0-150 PSIG . . . MODEL P132



BULLETIN MPT-1
contains complete specifications on the foregoing pressure transducer models.

All matters pertaining to sale or use of instruments of our manufacture are handled by engineering personnel directly from our Los Angeles plant.

Please feel free to wire or telephone us collect whenever we may be of service.

Statham
LABORATORIES
13401 W. Olympic Blvd., Los Angeles 64, Calif.

For more information circle **52** on inquiry card.

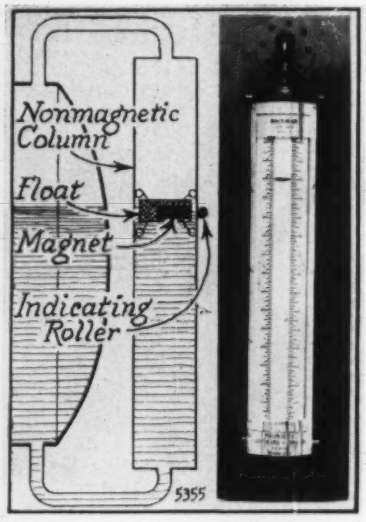
NEW INSTRUMENTS

liquids having a specific gravity of 0.40 or more; can also be provided with special-purpose anti-vibration mercury switches; can be furnished in materials to meet almost any corrosion problem.—*Magnetrol, Inc.*, 2110 *S. Marshall Blvd., Chicago* 23, *Ill.*

For more information circle **208** on inquiry card.

Liquid Level Gage

New "Magnalux" shows height of any liquid including liquefied gases stored under pressure; can be used



on existing tanks without cutting openings; is simple to install. Drawing shows essentials. Indicating roller is enclosed within a plastic raceway filled with an inert gas. On each side of raceway are scales graduated in any other convenient units.—*Liquidvision Gauge & Control Corp., P. O. Box* 51, *Oceanside, Long Island, N. Y.*

For more information circle **209** on inquiry card.

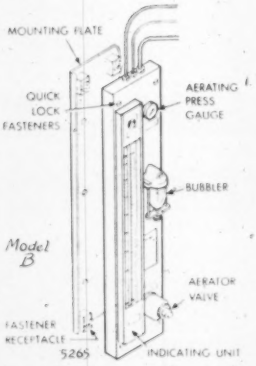
Remote-reading Tank Gage

New "Model 216 Remote Reading Tank Contents Indicator," for applications where panel space is limited, has a scale length of 20 in although occupying a panel space of 3 x 10¼ in; is available for either horizontal or vertical panel mounting. It is used with maker's automatic hydraulic-actuated tank-contents gaging systems, UL-approved for gaging hazardous liquids and available for tank pressures up to 200 psi. Where automatic level control is required, UL-approved switches are furnished. Tank unit is installed through a single 2-in diam opening in tank and, once installed, requires no further maintenance.—*The Liquidometer Corp.*, 41-03 36*th St., Long Island City* 1, *N. Y.*

For more information circle **210** on inquiry card.

Remote-reading Tank Gages

New "Series 1400 Petrometer Remote Reading Liquid Depth Gauges" can be installed on tanks up to 50 ft

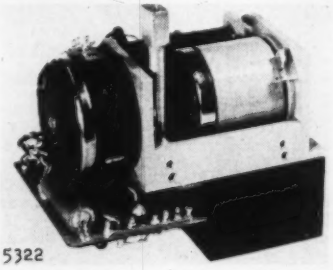


deep, above or below ground, up to ¼ mile away. Principle: hydrostatic pressure transmitted pneumatically to liquid column in indicator. Four models, all equipped with a push-button aerator valve for transmission line purging. Illustrated "Model B" also has a bubbler to indicate constant aeration; purging is automatic. "Model F" uses a flowmeter instead of a bubbler to indicate aeration. "Model M" is equipped with a manual compressor and air storage tank; purging accomplished by pressing aerator button.—*Liquidepth Indicators, Inc.*, 43-22 *Tenth St., Long Island City* 1, *N. Y.*

For more information circle **211** on inquiry card.

Voltage to Shaft-rotation Servo Converter

New "Model C104" miniature positional servo system (designed to MIL-E-5400 specs) comprises a two-stage



voltage-amplifier, a magnetic power-amplifier, a two-phase servomotor, a gear train, a follow-up resistor and a synchro transmitter (or other output device). It was designed originally for airborne measurements of airspeed, pressure-altitude, temperatures, control positions, etc. In association with a pickup, it converts pickup voltage into a proportional shaft rotation. —*Datran Engineering Corp.*, 3613 *Aviation Blvd., Manhattan Beach, Calif.*

For more information circle **212** on inquiry card.

Data-transmission Terminal

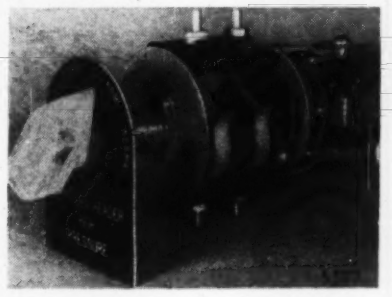
New "Model 912 Comvor," audio-frequency shift terminal for use in transmission and frequency multiplexing of telemetering, supervisory control and telegraph signals, is relatively insensitive to noise and ampli-

tude variations of communication link; is directly applicable to both frequency and time duration type telemetering systems. When used in conjunction with telephone dials, stepping switches or relay pyramids, it is said to be ideally suited for supervisory or remote control functions. When used in conjunction with microwave or carrier systems number of channels can be extended to at least 40 for telegraph and to 50 for supervisory control and telemetering. Equipment is available as a single transmitter or receiver, dual transmitter or dual receiver, or transmitter receiver for half or full duplex operation. Complete terminal mounts in a standard relay rack, and includes equipment and loop power supplies, a voltage-stabilized frequency-shift tone oscillator, 20-db transmitter filter, 20-db receiving filter, limiting amplifiers, discriminator, output keying circuit, and transmitter output, receiver input, and bias controls.—*Radio Frequency Laboratories, Inc., Boonton* 33, *N. J.*

For more information circle **213** on inquiry card.

Key-pointer-type Alarm

New "Electro-Larm" is self-contained; gives four visual indications by position of indicator key (which

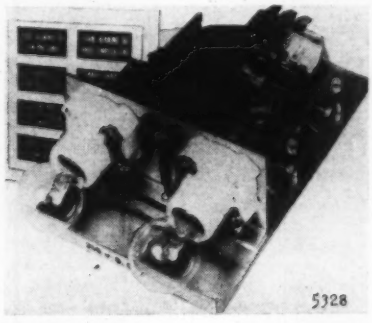


also contains a neon glow lamp): "Normal," "Alarm," "Pending," "Clear." Indicator key is illuminated in last three positions and an audible signal is sounded during both "Alarm" and "Clear" positions.—*Electro Devices, Inc.,* 4025 *Easton Ave., St. Louis* 13, *Mo.*

For more information circle **214** on inquiry card.

Window-type Annunciator

New "Electro-Pane" features a sequence of four different indications by use of three sealed mercury switches.



No small relay type contacts or coils; no auxiliary equipment required. Standard easily-obtained lamps are used. Unique feature is denoting four different indications by different col-

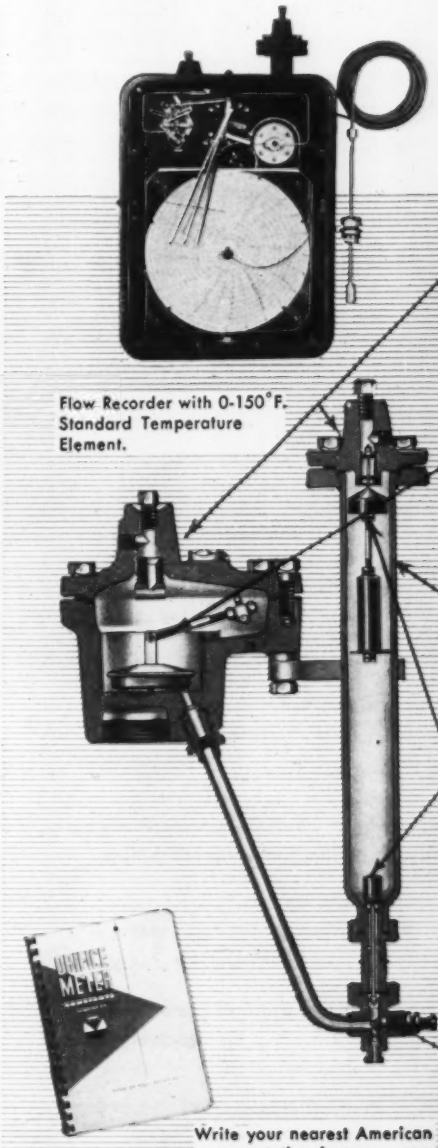
Meter Maintenance is SIMPLER... LESS COSTLY with American-Wescott Orifice Meters

Wherever precision measurement and economy of operation are required . . . at high or low flow rates . . . at varying temperatures . . . whether in recording, indicating, integrating or telemetering models, American-Westcott Series A-88 Orifice Meters are synonymous with accurate, dependable, trouble-free service and low maintenance costs.

American-Westcott Series A-88 standard mercury type orifice meters for working pressures to 5000 psi in interchangeable 10, 20, 50, 100 and 200-inch ranges give you complete versatility to meet any flow measurement requirements.

Recording • Indicating Integrating • Telemetering

Write for full details.



Flow Recorder with 0-150°F. Standard Temperature Element.

CLEANING manometer body interior is easily accomplished through removal of high and low-side covers. Does not affect meter accuracy.

CALIBRATION is tamper-proof through simple, positive adjustment of float lever arm length.

EXTENDED HIGH SIDE chamber gives additional over-range protection — interchangeable without altering manifold piping.

MERCURY CHECK VALVES give positive shut-off for over-range protection.

TEFLON-PACKED STUFFING BOX is pressure tight, nearly frictionless, never requires lubrication, free from maintenance troubles.

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For more information circle **53** on inquiry card.

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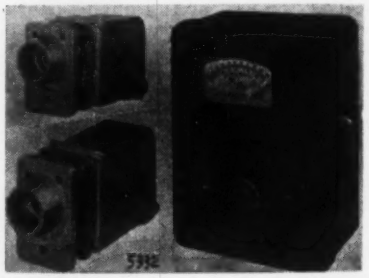
For more information circle **54** on inquiry card.

ors of illuminated nameplate, through use of plastic color filters and a diffusing prism which insures uniform nameplate lighting.—*Electro Devices, Inc., 4025 Easton Ave., St. Louis 13, Mo.*

For more information circle **215** on inquiry card.

Photoelectric Control

New "Densitometer Set P4S" consists of a light source, a photoelectric scanner and a control unit embodying

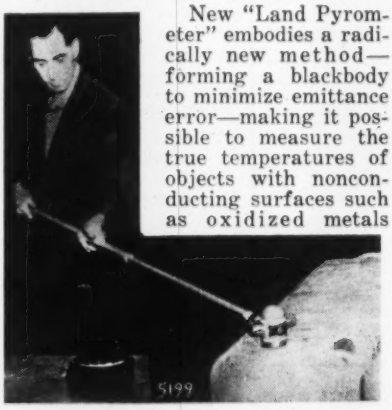


an electrical indicating instrument with two scales: "percent transmission" and "optical density." Control operation is provided at any light transmission value from 90% to 0%. Green light on front of control unit indicates normal condition; red light indicates excess smoke or density condition.—*Electronics Corporation of America, 77 Broadway, Cambridge 42, Mass.*

For more information circle **216** on inquiry card.

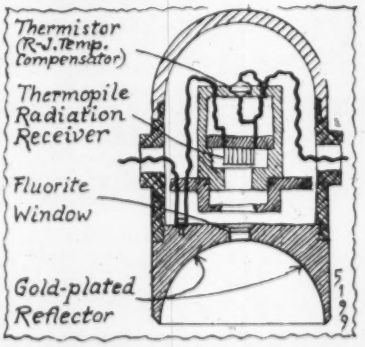
TEMPERATURE

Surface Pyrometer



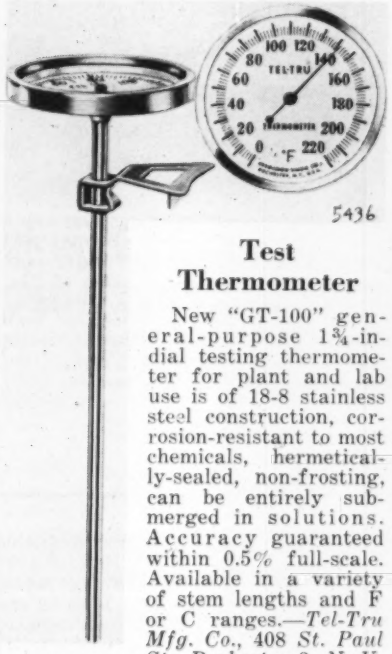
New "Land Pyrometer" embodies a radically new method—forming a blackbody to minimize emittance error—making it possible to measure the true temperatures of objects with nonconducting surfaces such as oxidized metals

and refractories (for which contact thermocouples, etc., are unsuitable) provided only that surface be fairly



flat and larger than a 2-in circle. Models are available with scales calibrated 100-800, 400-1700 and 1000-2400°F (also 50-400, 200-900 and 500-1300°C). Instrument can be used also to determine the emittance of any surface by taking one reading in normal manner and a second reading with a blackened hemisphere slipped inside reflector.—*Fielden Instrument Div., Robertshaw-Fulton, 2920 N. Fourth St., Philadelphia 33, Pa.*

For more information circle **217** on inquiry card.

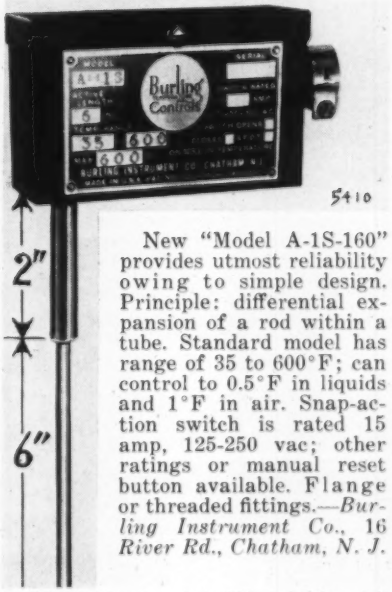


Test Thermometer

New "GT-100" general-purpose 1¾-in-dial testing thermometer for plant and lab use is of 18-8 stainless steel construction, corrosion-resistant to most chemicals, hermetically-sealed, non-frosting, can be entirely submerged in solutions. Accuracy guaranteed within 0.5% full-scale. Available in a variety of stem lengths and F or C ranges.—*Tel-Tru Mfg. Co., 408 St. Paul St., Rochester 3, N. Y.*

For more information circle **218** on inquiry card.

Differential-expansion Thermostat



New "Model A-1S-160" provides utmost reliability owing to simple design. Principle: differential expansion of a rod within a tube. Standard model has range of 35 to 600°F; can control to 0.5°F in liquids and 1°F in air. Snap-action switch is rated 15 amp, 125-250 vac; other ratings or manual reset button available. Flange or threaded fittings.—*Burling Instrument Co., 16 River Rd., Chatham, N. J.*

For more information circle **219** on inquiry card.

TC Reference Junction

New reference junction for thermocouple circuits, originally developed

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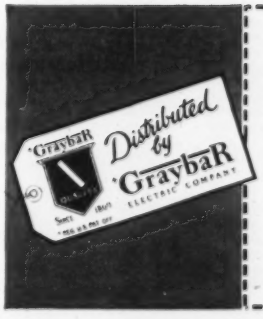

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For more information circle **55** on inquiry card.

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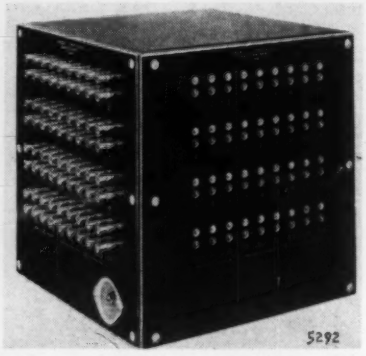
For more information circle **56** on inquiry card.

NEW INSTRUMENTS

for test-cells where potentiometer recorders measure pressures, etc., permits measurement of temperatures with the same strip-chart recorder, thus obviating need for a pyrometer; is available in a variety of sizes; can be used in ambient temperatures from

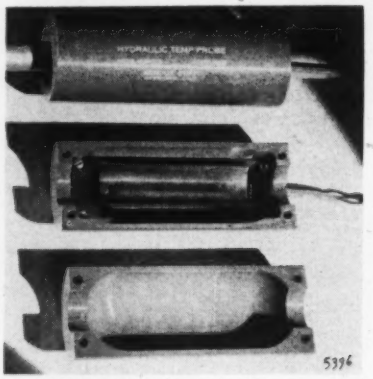


–65°F to 300°F. RJ temperature is maintained within 1F° (or better if necessary).—*Thermo Electric Co., Inc., Saddle River Township, Rochelle Park Post Office, N. J.*

For more information circle **220** on inquiry card.

Thermometric Elements for Hydraulic Lines

New "Series 8000 Probes" make it possible to measure temperatures anywhere in a hydraulic network without

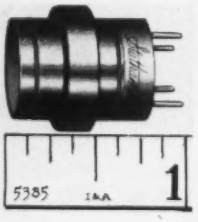


disturbing operation of system: one is placed around hydraulic line at each point of interest. Split-cylinder casting thermally isolates section of line; within cylinder a spring-loaded saddle is brought to bear against line wall. Saddle contains thermometric resistance element.—*Arnoux Corp., Dept. IA-3, Box 34628, Los Angeles, Calif.*

For more information circle **221** on inquiry card.

PRESSURE

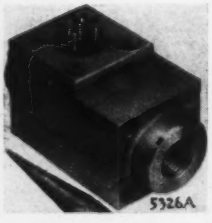
Miniature Pressure Pickups



New miniature pressure pickups employ maker's unbonded strain gage; are available in models for 0-5 to 0-150 psia, ±2.5 to ±25 psid, 0-5 to 0-150 psid, and 0-5 to 0-150 psig; are said to "have the highest natural frequencies of any strain gage type"; are relatively insensitive to static or vibratory accelerations along any axis. No epoxy resins are employed as pressure seals, and surface of diaphragm is homogeneous. Thermal zero shift is not more than 0.01% per F°; change in sensitivity is not more than 0.01% per F° between –65° F and 250°F.—*Statham Laboratories, Inc., 12401 West Olympic Blvd., Los Angeles 65, Calif.*

For more information circle **222** on inquiry card.

Differential-pressure Pickups



New pickups for differential pressure measurements at line pressures up to 2000 psi feature a diaphragm held at its rim in a rigid case and connected to an unbonded-wire strain-gage bridge, whose electrical output is proportional to difference between the two pressures. Models are available with d/p ranges from 0-10 to 0-1000 psi, all adjustable so that operating range either straddles or falls to one side of 2000-psi reference. Standard units operate with a-c or d-c excitation voltages of 6, 12, or 15, with bridge resistances of 350, 600, or 800 ohms, and minimum full-scale outputs of 20, 40, or 50 mv respectively. Hysteresis is no more than 0.25% of full scale.—*Dynamic Instrument Co., Inc., 28 Carleton St., Cambridge, Mass.*

For more information circle **223** on inquiry card.

Draft and D-p Gages

New "Minified Straight Line Pointer Gages" are close to half the size of maker's standard gages; measure

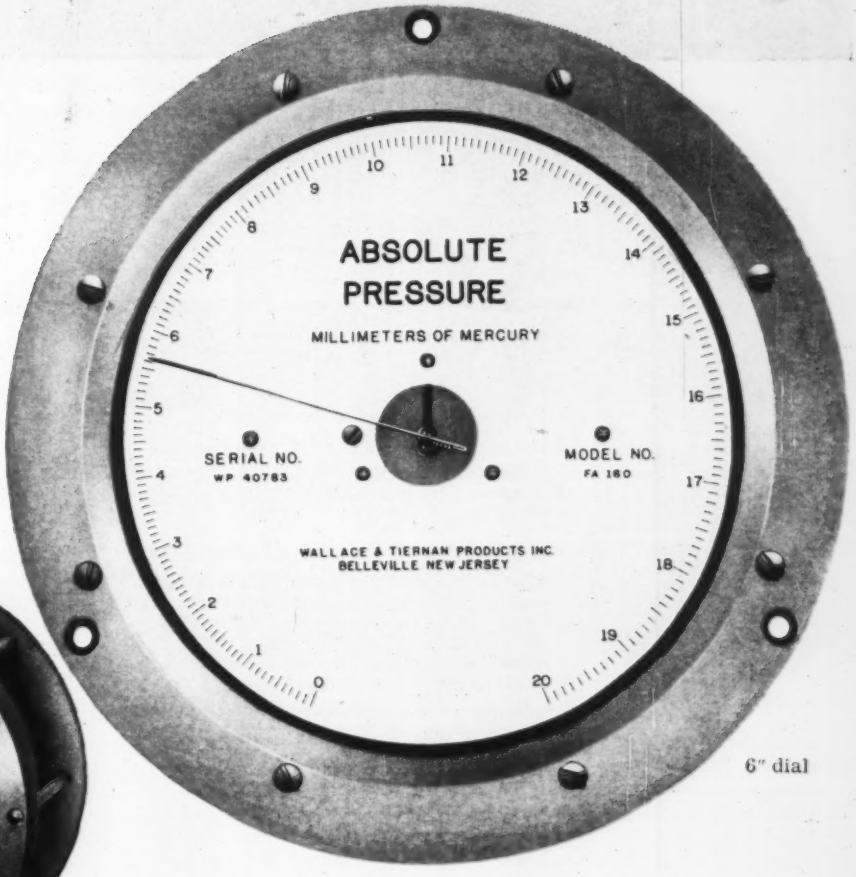
pressure, vacuum or differential pressures; include receiver type gages for use with pneumatic transmitters; feature non-parallax pointers, "everlasting" 5-in translucent glass scales, in-

ABSOLUTE PRESSURE INDICATOR

. . . FOR DEEP VACUUM WORK

Measures *pressure* directly from ZERO ABSOLUTE to atmospheric

. . . swiftly and precisely



6" dial

2¾" dial

TYPE FA-160

Used as a pressure indicator in any system employing a vacuum.

- All readings are relative to ZERO ABSOLUTE.
- Dial *reads directly.*
- Accurate to 1 part in 300 over full scale.
- Sensitive to 1 part in 500 in *all* ranges.
- No auxiliary indicator or corrections for ambient pressure changes required.
- Protected against sudden pressure surges.
- Ranges:

0— 50mm Hg.	0—410mm Hg.
0—100mm Hg.	390—800mm Hg.
0—200mm Hg.	0—800mm Hg.

- Dial Sizes: All ranges in either 2¾" or 6" dia.

For additional information on W&T Absolute Pressure Indicators, write today for Publication No. TP-28-A.

WALLACE & TIERNAN
INCORPORATED
PRECISION INSTRUMENTS AND ELECTRICAL MECHANISMS
25 MAIN ST. BELLEVILLE 9 N. J.
In Canada: Wallace & Tiernan, Ltd. Toronto

A-102

For more information circle **57** on inquiry card.

More Engineers on A-N and civilian projects are proving—

It pays to specify

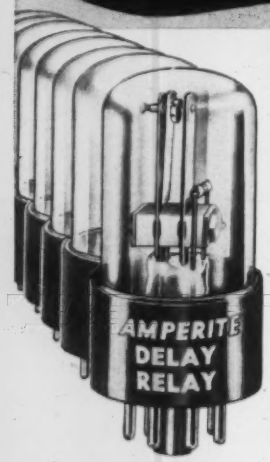
AMPERITE

DELAY RELAYS

and

BALLAST REGULATORS

...they're finest *...cost less!*



STANDARD

Thermostatic DELAY RELAYS

MOST COMPACT, HERMETICALLY SEALED

Provide delays ranging from 2 to 150 seconds.

- Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.
- *Hermetically sealed.* Not affected by altitude, moisture, or other climate changes.
- Circuits: *SPST only* — normally open or normally closed.

MINIATURE

Amperite Thermostatic Delay Relays are compensated for ambient temperature changes from —55° to +70°C. Heaters consume approximately 2 W. and may be operated continuously. The units are *most compact, rugged, explosion-proof, long-lived,* and — *inexpensive!*

TYPES: Standard Radio Octal, and 9-Pin Miniature.

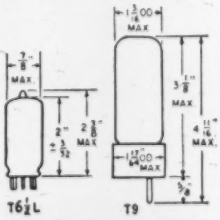
PROBLEM? Send for Bulletin No. TR-81

Also — a new line of **Amperite Differential Relays** — may be used for *automatic overload, over-voltage, under-voltage* or *under-current protection.*

T9 BULB

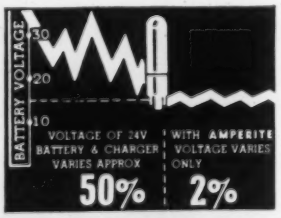
BALLAST REGULATORS

- Amperite Regulators are designed to keep the current in a circuit ***automatically regulated*** at a definite value (for example, 0.5 amp).
- For currents of 60 ma. to 5 amps. *Operates on A.C., D.C., Pulsating Current.*
- Hermetically sealed, light, compact, and most inexpensive.



T6½L T9

Amperite Regulators are the simplest, most effective method for obtaining ***automatic regulation*** of current or voltage. ***Hermetically sealed,*** they are not affected by changes in altitude, ambient temperature (—55° to +90°C), or humidity. Rugged; no moving parts; changed as easily as a radio tube.



Write for 4-page Technical Bulletin No. AB-51

AMPERITE CO. Inc., 561 Broadway, New York 12, N. Y.

In Canada: Atlas Radio Corp., Ltd., 560 King St. W., Toronto 2B

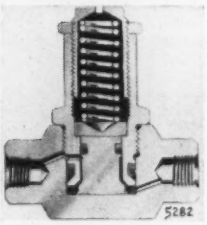
For more information circle **58** on inquiry card.

NEW INSTRUMENTS

ternally illuminated, removable individual elements.—*Ellison Draft Gage Co., Inc.,* 548 *W. Monroe St., Chicago 6, Ill.*

For more information circle **224** on inquiry card.

Pressure-gage Protector



New "Adjustable Gage Protector" is designed for use in hydraulic systems with working pressures up to 10,000 psi. Springs are available for standard maximum gage reading from 15 to 5000 psi. When line pressure reaches spring setting, plunger shuts off gage instantly; opens instantly when pressure falls. New design: spool-like plunger within a removable cartridge. Connections are in-line. Spring pressure adjustments, or changes of cartridge, are made without removing from line.—*Republic Mfg. Co.,* 15655 *Brookpark Road, Cleveland* 11, *Ohio.*

For more information circle **225** on inquiry card.

Pressure-gage Protector

New model of maker's Pressure Snubber, heretofore made only in brass, is available in stainless steel. It can be adjusted without disturbing line connections. Three pins used in combinations offer 13 graduations of damping adjustment. Pressure rating 5000 psi.—*Tube & Hose Fittings Div., Parker Appliance Co.,* 17325 *Euclid Ave., Cleveland* 12, *Ohio.*

For more information circle **226** on inquiry card.

AVIATION

Airplane Lift-measuring Instrumentation

New "Speed Control System" tells pilot best speed to fly on landing, take-off and other low-speed flight conditions. It enables pilot to extract maxi-

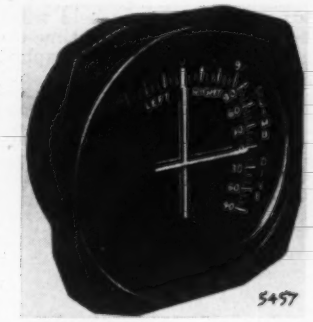
mum aerodynamic efficiency from his aircraft. Principle: continuous measurement of (1) wing leading edge pressure and (2) entrance air angle at leading edge. Changes in wing lift are caused by varying loads, power settings, landing flap positions, maneuvering acceleration, ground effect,

density altitude, wind gusts and other factors. This information is passed electrically (not electronically) through "Lift Computer" (not illustrated) to instrument on panel. To fly at "best" speed, pilot merely centers pointer. Complete system weighs less than 11 lbs.—*Safe Flight Instrument Corp., White Plains, N. Y.*

For more information circle **227** on inquiry card.

Aircraft Instruments

New "AN 3C-2E" two-element aircraft instruments utilizing maker's coaxial mechanisms are said to have



"greater durability and performance stability than many larger and heavier existing instruments"; are also available with one, three or four elements (AN3C-1E, AN3C-3E, AN3C-4E) as ammeters, voltmeters, temperature indicators and radio navigational instruments.—*Marion Electrical Instrument Co., Manchester, N. H.*

For more information circle **228** on inquiry card.

Cabin-pressure Control

New cabin pressure control system with proportional control characteristics is said to "introduce a new concept in cabin pressure control for airliners." It usually holds cabin-pressure rate-of-change below 300 feet per minute while aircraft is climbing or descending at a greater rate. (300 fpm is one-fourth that in elevators in some New York skyscrapers.) Safety: system continuously guards against exceeding pressure limits in relation to aircraft's structural strength. On landing, cabin pressure decreases at a comfortable rate to correspond to altitude of field. Since no cabin air flows through sensing mechanism, tobacco tar, etc. cannot affect its function.—*Kollsman Instrument Co., 80-08 45th Ave., Elmhurst 73, N. Y.*

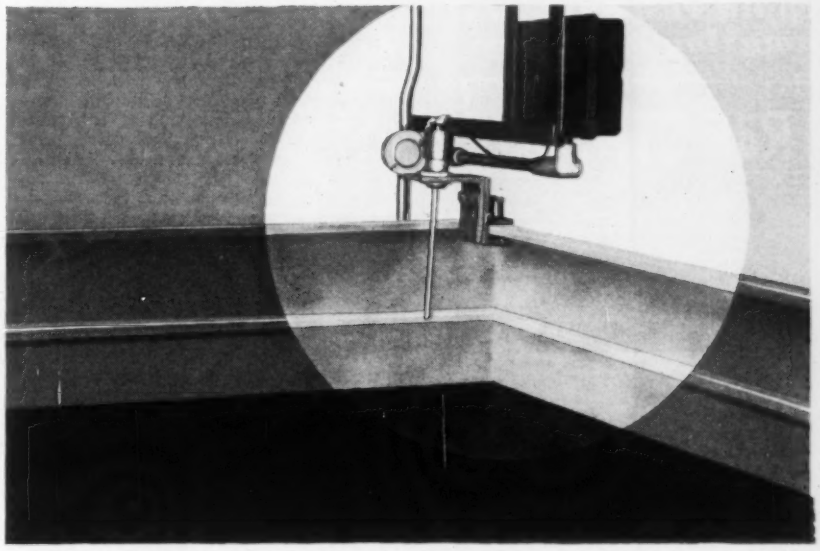
For more information circle **229** on inquiry card.

Airplane Fire Alarm

New "Visual Fire Detector" does not utilize vision: it is an optical fire detector utilizing a miniature photoconductive cell which is infrared sensitive. This cell detects flicker which distinguishes flames from constant-radiation lamps, etc. Flame's radiation causes a pulsating signal to be transmitted to control panel which, being frequency-sensitive to this signal, actuates fire warning system. An optical filter (cover over the cell) passes only infrared radiation.—*Electronics Corporation of America, 77 Broadway, Cambridge 42, Mass.*

For more information circle **230** on inquiry card.

TEKTOR Keeps Hershey Chocolate from Overflowing Open Tank

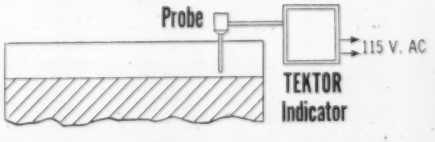


How to keep a 90,000 pound open milk chocolate storage tank from overflowing was the problem faced by the Hershey Chocolate Corporation.

Hershey Engineers found a solution by installing a Fielden TEKTOR High-Level Indicator Controller and Probe. Now, when chocolate level rises to 4 or 5 inches from the tank lip, this simple but dependable instrument flashes and sounds a warning so that the inflow of chocolate can be stopped.

Why TEKTOR Level Control is YOUR Solution

- Indicates or controls level of fluids, powders, solids (conducting or non-conducting)
- Electronically controls level as close as 1/16"
- A ready-to-install unit
- No moving parts . . . only one radio tube
- Regular plant personnel can maintain it
- Low first cost . . . low operating cost.



A TEKTOR probe is installed vertically and its electrical capacity changes when chocolate level is 4 or 5 inches from the lip of the tank. This de-energizes the Indicator relay and switches on the warning light and alarm.

Robertshaw-Fulton CONTROLS COMPANY

Send this coupon today, and find out how Fielden Simplified Instrumentation can solve your process control problems . . . accurately and economically.

FIELDEN INSTRUMENT DIVISION
2920 N. Fourth St., Dept. A, Philadelphia 33, Pa.
Please send me bulletins about your low-cost, accurate controls.

☐ TEKTOR Level Control
☐ Electronic Temperature Control
☐ Resistance Thermometer Recorder
☐ Proximity Meter

NAME_____ TITLE_____
COMPANY_____ ADDRESS_____
CITY_____ STATE_____

For more information circle **59** on inquiry card.

RESISTANCE THERMOMETER ELEMENTS

rapid response . . . amazing accuracy

RdF STIKON®

SN-1 ACTUAL SIZE
WEIGHT: 1/200 OZ.

Intended for surface temperature measurement and control, an RdF Stikon consists of a temperature-sensitive grid of very fine nickel wire bonded into a paper-thin wafer of flexible insulating material. Attached by cement to almost any surface anywhere, an RdF Stikon is unaffected by shock or vibration. The response is extremely fast and accurate.

Features of RdF Stikons

BN-1: Response fits curve defined by A-N Specification MIL-B-7990.
BN-3 & BN-4: Similar to BN-1 but smaller in size. Response curve differs from BN-1.
PN-1 & PN-2: Paper construction for low cost.
SN-1: High-temperature element.

SUMMARY OF CHARACTERISTICS

Type	Resistance at 70°F (ohms)	Temperature Range F*
BN-1	81.7	—100° to +300°
BN-3	50.	—100° to +300°
BN-4	200.	—100° to +300°
PN-1	50.	—100° to +180°
PN-2	200.	—100° to +180°
SN-1	100.	—100° to +500°

*For continuous operation — may be used intermittently at higher temperatures. See RdF Stikon Brochure T-54.

Type	Wafer Material	Size (Inches)
BN-1	Bakelite	½ x 1½ x .005
BN-3	Bakelite	5/16 x ¾ x .006
BN-4	Bakelite	5/16 x ⅞ x .006
PN-1	Paper	5/16 x ¾ x .006
PN-2	Paper	5/16 x ⅞ x .006
SN-1	Silicon-Glass	5/16 x 1 1/16 x .010

Types BN-1, BN-3 and PN-1 are marked to 0.2 ohms, while types BN-4, PN-2 and SN-1 are marked to 0.5 ohms.

In addition to the standard RdF Stikons tabulated above, Arthur C. Ruge Associates, Inc. manufactures special resistance thermometer elements tailored to specific customer needs.

Write today for RdF Stikon Brochure T-54.

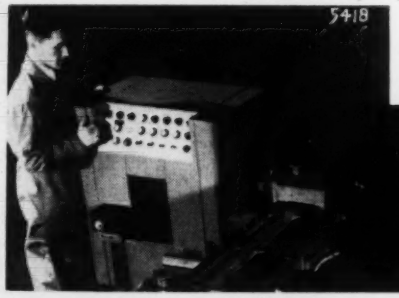
ACRA
Arthur C. Ruge Associates, Inc.
733 CONCORD AVE
CAMBRIDGE 38, MASS

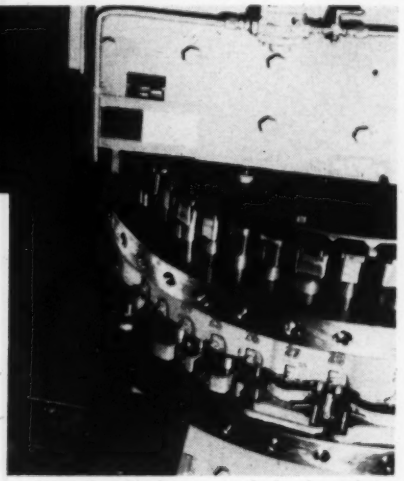
For more information circle **60** on inquiry card.

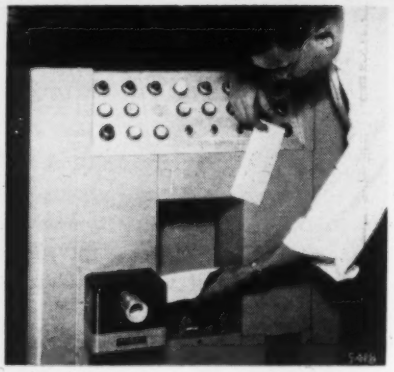
MACHINE AUTOMATION, GAGING, etc.

Machine-tool-operation Card-type Controller

New "Numerical Positioning Control" uses punched business-machine cards to control machine tools; can, it is said, "double or triple productivity of many machines on which it is installed." Standard card processing equipment is used for punching, sorting and stocking. Positioning information is punched into cards in decimal form and is not coded; this permits operator to read directions from card. Each card, as it is placed into standard card reader, contains complete information for at least one machining operation. Cards have adequate space also for miscellaneous directions such as operator's instructions. Among machine functions normally programmed: tool selection and indexing, sequencing of operation and initiating of automatic material-handling cycles. Major components: "Director," control panel, position Selsyn pick-up units, and d-c motor drives. System is completely automatic. Dimensions are consistently held within required tolerances. Such time-consuming jobs as positioning templates





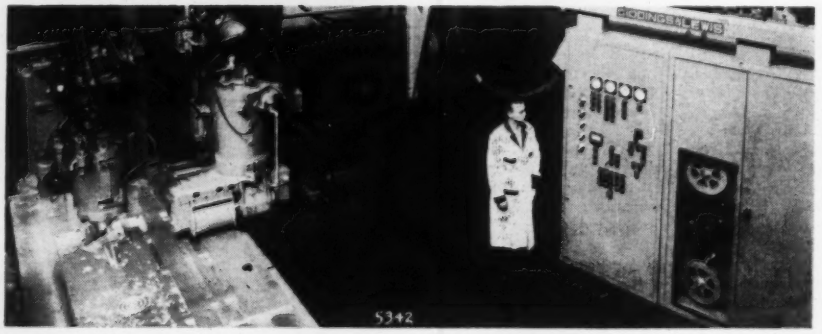


and tools, laying out hole locations and hand checking are eliminated.—*Specialty Control Dep't, General Electric Co., Schenectady 5, N. Y.*

For more information circle **231** on inquiry card.

Machine-tool-operation Mag-tape-type Controller

New "Numericord" is so called because machines are commanded by simple-decimal NUMERical data recORDed on magnetic tape. It is said to be "not only the first commercially-available system to operate from numerically-prepared tape, but also the first to control heavy-duty machines in production of large, complicated workpieces." Major components: (A) paper tape preparation unit, (B) electronic director which converts these paper-tape data into electrical command signals on magnetic tape; (C) control unit which "reads" commands off magnetic tape and in turn commands machine through (D) electromechanical apparatus, Amplidynes, etc. A and B can be installed remote from shop area. Example of versatility: spiral cut in left foreground of



CAN YOU MEASURE NOTHING ACCURATELY?

Now *Doelcam* Magnetik Null Indicator

EXCLUSIVE FEATURES

- **High Sensitivity**
- **Linear Deflection**
- **Magnetic Converter**
- **Isolated Input**
- **Low Noise Level**

Write for Bulletin NI4

THE DOELCAM Magnetik Null Indicator, Model 2HG-1, is *both* a null balance detector and a linear deflection indicator. It may be used as either a low level laboratory instrument where *accurate null* measurement is important, or as a fast measuring production test instrument where *linear* off-balance readings and ability to withstand rough usage are essential. All around improved performance is achieved by use of the unique DOELCAM Second-Harmonic Magnetic Converter as the input modulator.

CHARACTERISTICS

HIGH SENSITIVITY: 2 Microvolts per division. 0.003 Microamperes per division.

PROPORTIONAL DEFLECTION: Linearity over full scale range is within 5% accuracy.

ISOLATED INPUT: Input terminals are isolated from chassis and circuit ground.

LOW NOISE LEVEL: Less than 2 microvolts equivalent input. Insensitive to 60 or 120 cycle pickup.

EXCELLENT STABILITY: Zero drift less than 1 division per hour.

INDEPENDENT OF LINE VOLTAGE: No observable drift or change in sensitivity for line variations from 105 to 125 volts.

QUICK READING: Time constant of less than 1 second.

RUGGED: Not damaged by overrange of 1.5 volts d-c.

POLARITY SENSITIVE: Zero-center mirror-scale meter for polarity sensing measurements.

LOW MAINTENANCE: Only one vacuum tube. No moving parts except meter.

Doelcam

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H HONEYWELL

SOLDIERS FIELD ROAD
BOSTON 35, MASS.

Instruments for Measurement and Control

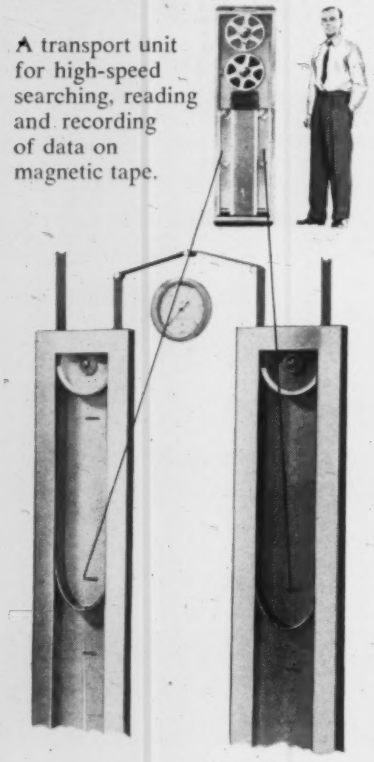
Synchros • Gyros • Amplifiers • Microsyns • Servo Motors

For more information circle **61** on inquiry card.

DataReader

Model 546

A transport unit for high-speed searching, reading and recording of data on magnetic tape.



Vacuum column tape control

Vacuum method of sensing provides servo control of the reel drive motors, resulting in a highly sensitive tape feed control. Only a short length of tape need be accelerated to bring the tape to full speed. Exceptionally rapid acceleration and minimum tape strain are realized, since no mechanical system inertia need be overcome.

PERFORMANCE:

RAPID START—STOP—REVERSE—from stop to full speed in 6 milliseconds.

HIGH TAPE SPEED—optional single speed of 30, 40, 50, 60 or 75 in/sec.

TWO-DIRECTION SEARCH—either direction, automatically at full speed.

REMOTE OPERATION—forward, reverse, stop, rewind and selection of reading and writing.

END-OF-TAPE SENSING—stops automatically at either end of tape.

RAPID REWIND—2400 ft. of ½" or ¾" tape in 3 minutes.

FOR FURTHER INFORMATION WRITE
ElectroData Corporation
Component Sales Division
460 No. Sierra Madre Villa
Pasadena 15, Calif.

ElectroData

An Affiliate of
CONSOLIDATED ENGINEERING CORPORATION
OF PASADENA, CALIFORNIA

ElectroData Corporation maintains a nationwide sales and service organization.

For more information circle **62** on inquiry card.

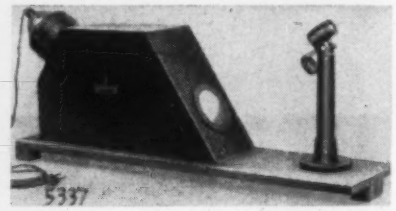
NEW INSTRUMENTS

workpiece. System can simultaneously control up to 5 machine axes in 3 dimensions and up to 22 auxiliary machine functions. Spoken instructions can be inserted on tape to warn attendant (for example) of inspection "stops" planned into machining program.—*Giddings & Lewis Machine Tool Co., Fond du Lac, Wis.*

For more information circle **232** on inquiry card.

Strain Polariscope

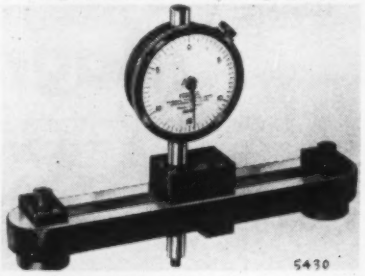
New "Askania Glass Strain Viewer" is for testing objects of glass, plastic or other transparent materials for absence of thermal or mechanical strain, by means of polarized light; can be operated by untrained personnel.—*Epic Inc., 154 Nassau St., New York 38, N. Y.*



For more information circle **233** on inquiry card.

Adjustable Depth Gages

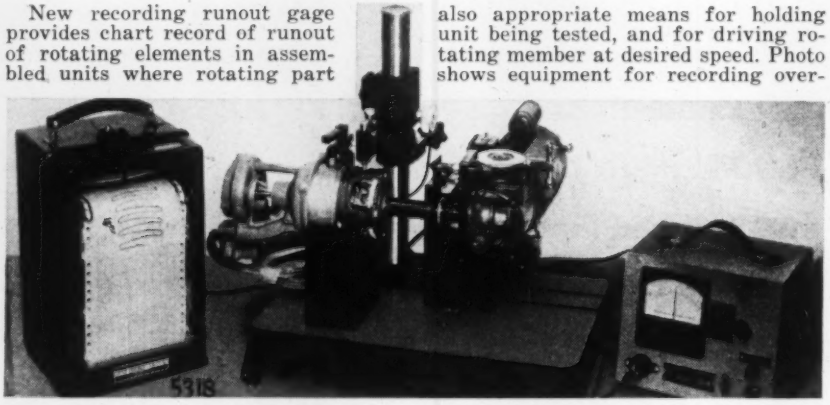
New "Models 75 P-10 and 75 P-11" obviate need for users designing and building their own depth gages; will gage a variety of slots, holes, keyways, etc., from 0 to 1 in and from 1 in to 2 in, respectively.—*Federal Products Corp., 1144 Eddy St., Providence 1, R. I.*



For more information circle **234** on inquiry card.

Recording Runout Gage

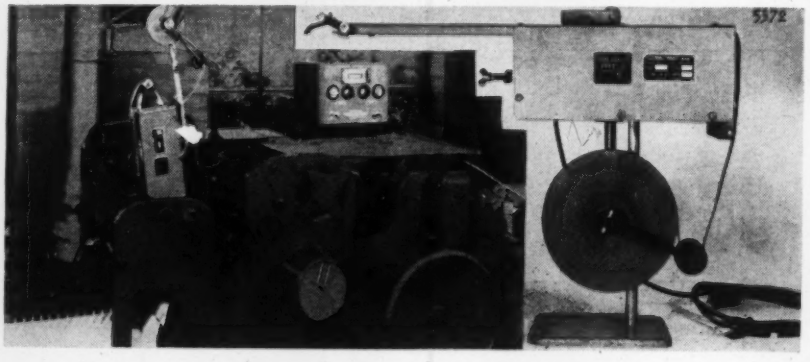
New recording runout gage provides chart record of runout of rotating elements in assembled units where rotating part can be reached with an external probe. Two sensitivities (10 and 50 microinches per chart division) are interchangeable at will. Instrument includes (1) maker's "Par-Ac" adjustable gage head mounted on vertical column; (2) drift-free electronic amplifier; (3) high-precision recorder; also appropriate means for holding unit being tested, and for driving rotating member at desired speed. Photo shows equipment for recording overall runout and bar-to-bar step measurement of commutator in an assembled motor: gage head with its stem extending through hole in motor housing, tip in contact with commutator.—*Cleveland Instrument Co., 735 Carnegie Ave., Cleveland 15, Ohio.*



For more information circle **235** on inquiry card.

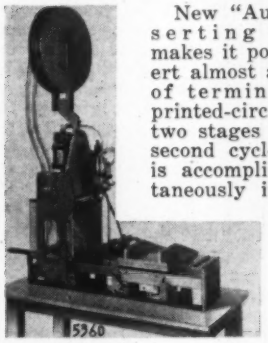
Automatic Counter-tape Inserter

New "Tape-Inserter," commanded by maker's "Preset Decitron," inserts a tape (in any length from 1 in to 6 in) between production items when each count of 25 (or 10, or 50 or any number between 1 and 100) is reached. This facilitates visual count and helps packaging. Shop photo shows use on a Beasley & French envelope machine.—*Post Machinery Co., 155 Elliott St., Beverly, Mass.*



For more information circle **236** on inquiry card.

Automatic Inserter for Printed-circuit Boards

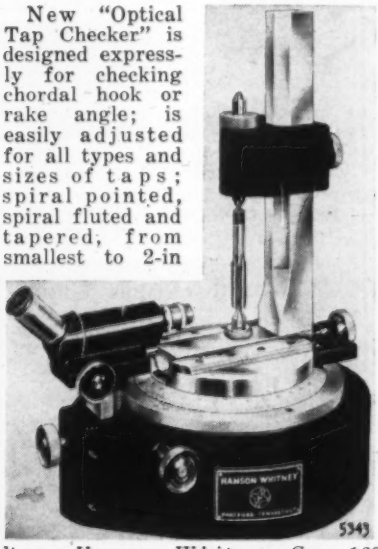


New "Automatic Inserting Machine" makes it possible to insert almost any number of terminals into a printed-circuit board in two stages within a 3-second cycle. Insertion is accomplished simultaneously in any pattern. Terminals or pins being self-retaining, they will not vibrate loose during additional assembly or other operations before permanent soldering. Operation is completely automatic: terminals or pins in chain form are fed from two reels simultaneously.—*Malco Tool and Mfg. Co., Dept. IAP, 4025 W. Lake St., Chicago 24, Ill.*

For more information circle **237** on inquiry card.

Visual Tap Checker

New "Optical Tap Checker" is designed expressly for checking chordal hook or rake angle; is easily adjusted for all types and sizes of taps; spiral pointed, spiral fluted and tapered, from smallest to 2-in

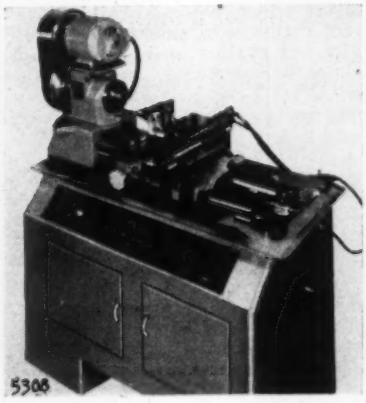


diam.—Hanson-Whitney Co., 169 Bartholomew Ave., Hartford 2, Conn.

For more information circle **238** on inquiry card.

Boring Machine

New "Unimatic" features automatic controls and timers for repeated cycles. Job set-up is said to have been



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Flow Sheet

Hoke reports on fluid control

we're giving you the needle

. . . to help you control small flow rates easily and accurately. The needle point in a Hoke Metering Valve is just 8° wide and it takes 20 turns of the handle to move the point ⅜ of an inch, the effective throttling length. In addition to this precise control, the Metering Valve has an O-ring stem seal (. . . so tight it'll pass a Helium Leak Test) and is available for instrument panel mounting.

Interested? . . . write for catalog and data sheets.

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. . . but you'll be amazed to see how easy it is to connect Hoke valves to tubing the Swagelok way. No swaging, no sweat, no swearing . . . in fact, it's no trick at all to achieve a permanent valve-to-tube connection with a turn and a quarter of a wrench. Hoke makes precision needle valves, on-off toggle valves, check valves — in brass and stainless — equipped with Swagelok tube ends.

Ask for Bulletin SV854.

HOKE

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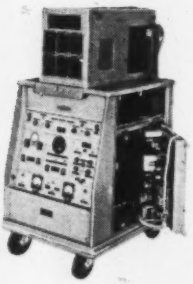
Fluid Control Specialists

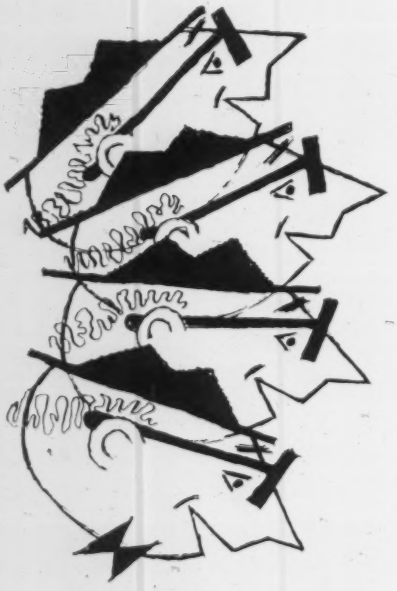
231 S. DEAN STREET, ENGLEWOOD, N. J.

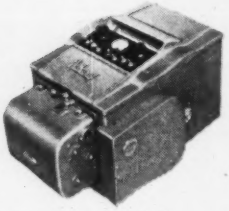
For more information circle **63** on inquiry card.

Let Hathaway solve your measurement problems

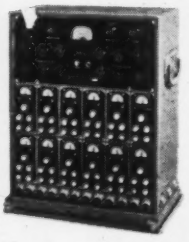


Hathaway SC-16B
Oscillograph

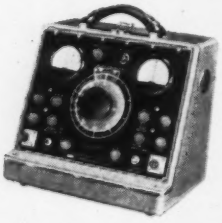




Hathaway S14-E
Oscillograph



Hathaway MRC-21
Strain Gage Control Unit



Hathaway RS-20
Portable Strain Indicator

For more than 15 years the Hathaway Instrument Company has been developing and manufacturing precision instruments for use in research and testing. Qualified Hathaway engineers would welcome your inquiries on measurement problems.

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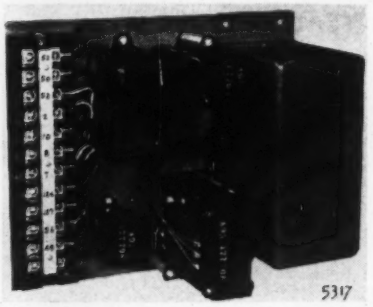
For more information circle **64** on inquiry card.

simplified "to the point where very short runs can be efficiently made using unskilled labor, and at less cost than the work could be done in any other manner by skilled mechanics." "Unimatic" was built originally for maker's own contract division, after which fifty machines were tested for two years by precision manufacturers before sales were instituted.—*Atlantic Instrument Corp., Norwood, Mass.*
For more information circle **239** on inquiry card.

Anti-repeat Control

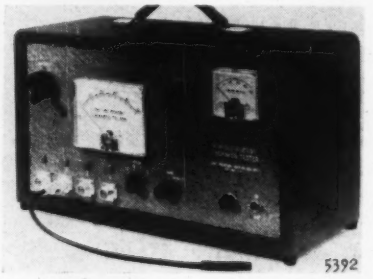
New anti-repeat control for maximal safety of metalworking presses utilizes transistors (instead of relays



as in maker's other models) to perform necessary switching functions, thus greatly prolonging service life.—*Clark Controller Co., 1146 E. 152nd St., Cleveland 10, Ohio.*
For more information circle **240** on inquiry card.

Plating-thickness Gage

New "Dermitron" makes possible 100% production inspection of thicknesses of (1) metals deposited on



metals, (2) metals on non-conductors, and (3) non-conductors on metals. It is said to be "the first non-destructive tester which will accurately give direct readings of thicknesses of virtually any coating on any base."—*Unit Process Assemblies, Inc., 75 E. 4th St., New York 3, N. Y.*
For more information circle **241** on inquiry card.

Indicating Hole Gages

New "Model 1250P Series" comprises four gages for checking hole diameters between ½ in and 8 in (maximum size for each gage twice its minimum). Feature is positive centralization, whereby gage can be accurately set without master rings if desired: directly to flat surfaces of gage blocks and applied to radiused

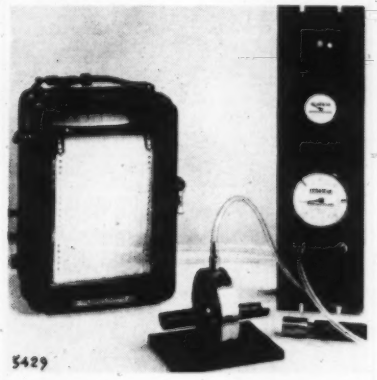
5428

surface of a hole with no significant error; transfer accuracy in this case is better than 50 microinches.—*Federal Products Corp.*, 1144 *Eddy St., Providence* 1, *R. I.*

For more information circle **242** on inquiry card.

Recording Air Gage

New "Dimensionair-Recorder" makes it possible to obtain permanent records of air gage measurements. It combines maker's "Dimensionair," panel mounted to facilitate installation, with a Bristol strip-chart re-



5429

corder. A special gage head is used for continuously measuring sheet or strip material. Also available, devices which will automatically adjust machine so as to make it produce material of required thickness.—*Federal Products Corp.*, 1144 *Eddy St., Providence* 1, *R. I.*

For more information circle **243** on inquiry card.

MICROSCOPES, CAMERAS, ETC.

Measuring Magnifier

New seven-power measuring magnifier has transparent sides to permit maximal illumination of object under study. Removable metal base permits magnifier to be used without scales,

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NEW INSTRUMENTS

or with any one of four available scales. Magnifier comes with plastic carrying and storage case.—*Bausch & Lomb Optical Co., Rochester, N. Y.*

For more information circle **244** on inquiry card.

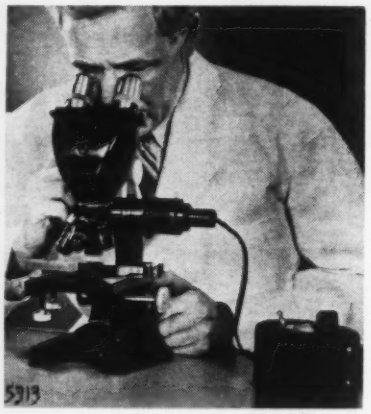
Binocular Microscope

New "Kern Swiss Prismatic Binocular Microscope" provides an erect stereoscopic image which eliminates eyestrain. Wide field and ample working space allow easy, unhampered work. Magnification can be varied from 7 to 100 with 6 pairs of lenses, 2 lens turrets and 2 pairs of eyepieces. Choice of 6 stands and 4 light systems. — *Karl Heitz, Inc., 480 Lexington Ave., New York 17, N. Y.*

For more information circle **245** on inquiry card.

Metallurgical Microscope

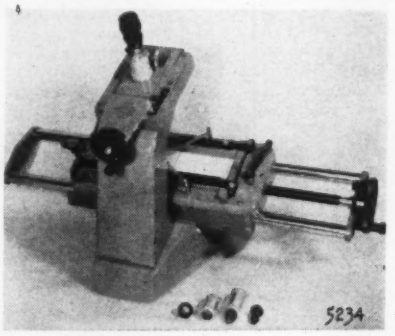
New "Model DMETR" features several design innovations, among them an oversized focusing stage with interchangeable stage plates, which adapt it quickly for work with either transparent or opaque specimens; a fine-adjustment focusing knob located at table level to permit operators to work with their arms in a relaxed position, and an accessory lens for concentrating external illumination into the microscope for photomicrographic use. ★ Also available, a supplementary lens that concentrates illumination from outside sources and permits external light sources to be moved as much as 7 in from microscope. ★ Also available, "Tri-vert Illuminator" (shown jutting from side) that permits study of opaque or semi-opaque specimens in brightfield, darkfield, or polarized light.—*Bausch & Lomb Optical Co., Rochester, N. Y.*



For more information circle **246** on inquiry card.

Measuring Microscope

New "Optical Measuring Instrument MAM 300/60" made by Askania-Werke A.G. has measuring ranges of



300 mm in x-direction and 60 mm in y-direction, graduated optionally in millimeters or inches. Accuracy of reading 0.01 mm. Four interchangeable objectives of 12, 24, 54 and 74X magnifications.—*Epic Inc., 154 Nassau St., New York 38, N. Y.*

For more information circle **247** on inquiry card.

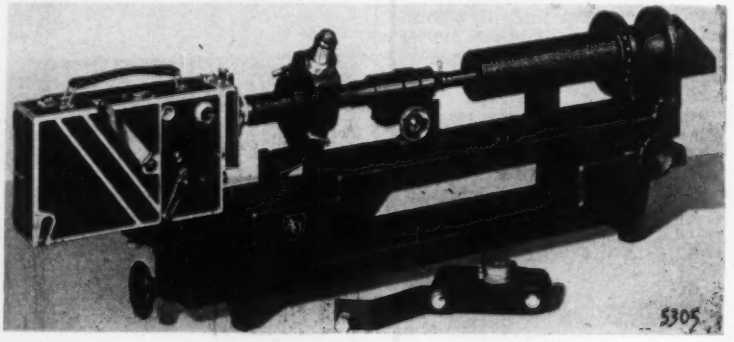
Stereoscopic Camera for Medical Research, etc.

New stereoscopic camera, capable of taking color or b&w 3-dimensional photographs "of unequalled accuracy" at close range, is especially suited for

High-temperature Microscope

New High Temperature Microscope, for both visual examination and photographic recording of specimens during their molten state in a microfurnace, transmits 80% of light to camera (either still or motion picture) and reflects 20% to visual eyepiece. Choice of objective and eyepiece magnifications. Photo shows "Cine-Kodak" in operating position and (below) a 35-mm still camera with adapter.—*Instrument Div., American Optical Co., Buffalo 15, N. Y.*

For more information circle **248** on inquiry card.



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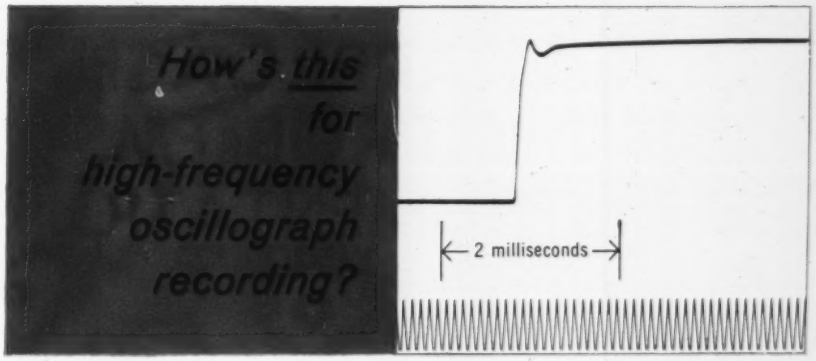
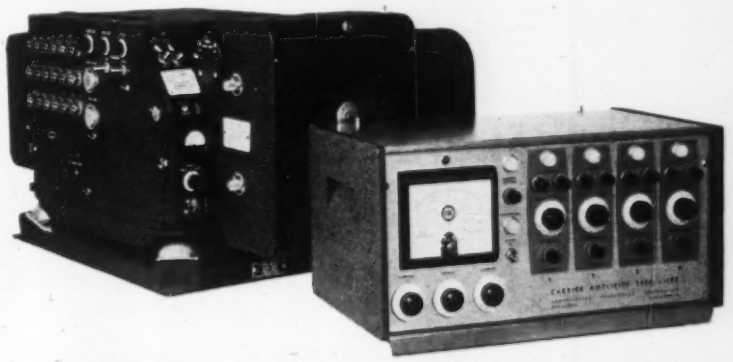


Here's a multi-channel data-recording system flat to 3000 cps and capable of stretching 1/100th of a second out over a full 5-inch length of record. It's exactly what's needed for capturing high-speed transient data in clear, graphic form, easily interpreted. The combination of these two instruments—the 5-114 Recording Oscillograph and the 1-127 Carrier Amplifier—is invaluable in blast measurements, rocket studies and high-frequency shock and vibration analysis . . . all fields of increasing importance.



5-114 RECORDING OSCILLOGRAPH... most widely used, most versatile oscillograph in the world today. Either 18 or 26 traces on 7" paper or film. High-speed accessory magazine holds 250 ft. of paper and permits record speeds *up to 500"/sec.* SEND FOR CEC BULLETIN 1500C-X4.

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For more information circle **66** on inquiry card.

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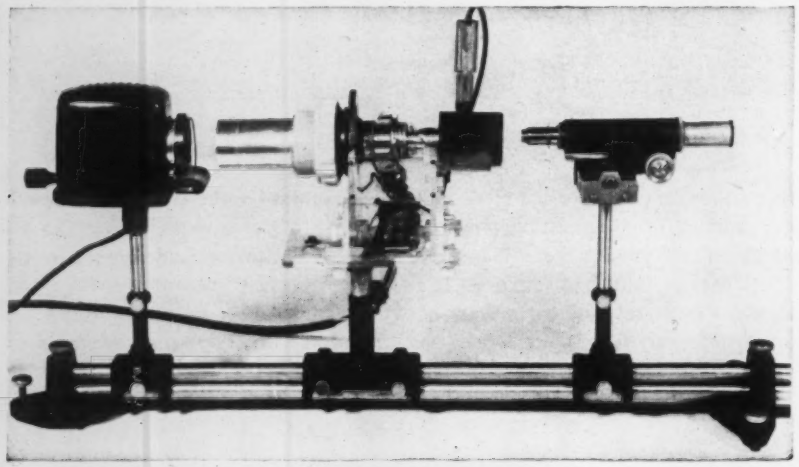

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For more information circle **67** on inquiry card.

medical, educational and general research uses. Its unique optical design eliminates distortions of ordinary stereo cameras. Its operation is simple: all scales (bellows extension, inter-lens distance and parallax correction) are calibrated according to magnification or minification. Lens openings remain constant at a small aperture, providing maximum depth of field. A variable-intensity "strobe" flash, powered by a separate amplifier, is also calibrated according to magnification. (Heretofore, trial-and-error has been only way of taking stereo close-ups of human eye, skin lesion, etc.). New camera comes equipped with power supply, electronic flash, stand and viewer.—*Perkin-Elmer Corp., Norwalk, Conn.*

For more information circle **249** on inquiry card.

Macroscope

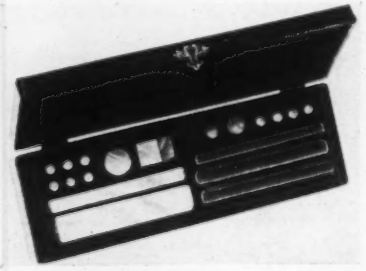
New macroscope for inspection and quality control on production lines is available in magnifications of 10X,

20X, or 40X; provides an erect image; can also be built into machines for constant examination of work in progress.—*Bausch & Lomb Optical Co., Rochester, N. Y.*

For more information circle **250** on inquiry card.

Optical Design Kit

New optical engineering experimental kit provides a choice of 19 pre-



cision components, all standard items available from stock.—*Houston Technical Labs, 2424 Branard, Houston, Texas.*

For more information circle **251** on inquiry card.

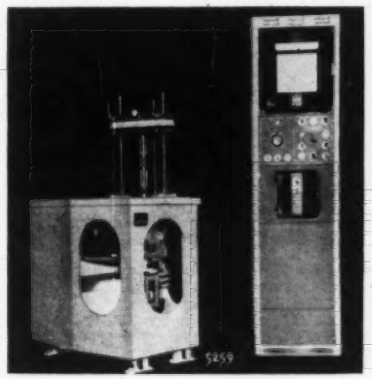
TEMPORARY INQUIRY CARD

If the inquiry card on page 1569 is not available, use temporary card on page 1482 or 1498.

MECHANICAL TESTING and INSPECTION

Creep-test Machine

New "Model BJL-1 Dynamic Creep-testing Machine" is claimed to offer "greater ease of set-up and compact-



ness, together with performance equal or superior to any comparable commercial machines, at a substantially lower price." Capacity: static force of 0 to plus-5000 lb and alternating force of 0 to plus-and-minus-4000 lb at 3600 cpm, with a maximum amplitude of 0.050 in; creep up to 0.375 in. —*The Ivy Co., 15 Merwin St., Norwalk, Conn.*

For more information circle **252** on inquiry card.

Hot-cold Tensile Tester

New "Model L-8" meets demand for apparatus to test rubber and elastomers at increasingly greater ex-

tremes of high and low temperatures; has range from –70°F to 550°F. For convenience of operation and maximum versatility, it comes in two units: testing instrument and conditioner.—*Scott Testers, Inc., 45 Blackstone St., Providence, R. I.*

For more information circle **253** on inquiry card.

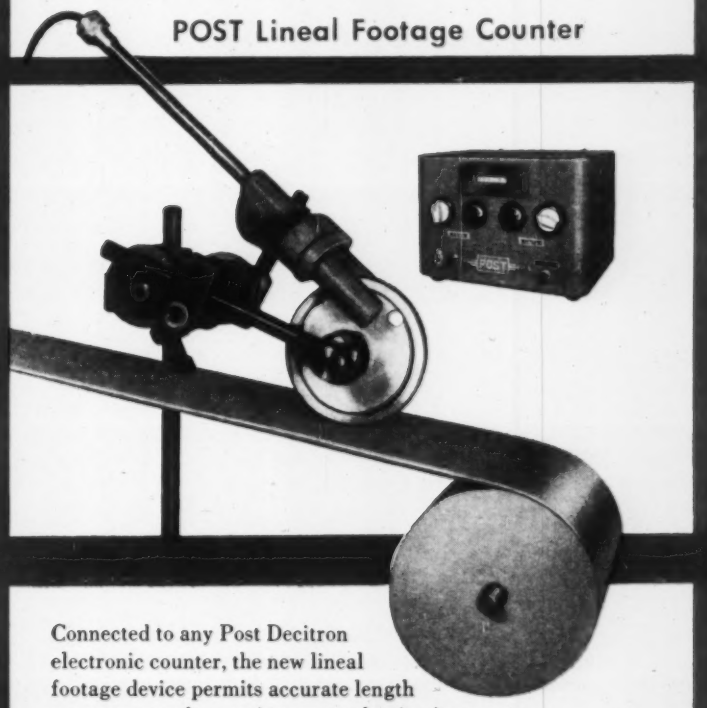
Metal Sorter

New "Model CE Cyclograph" is for non-destructively testing and sorting accidentally-mixed or incorrectly-processed metal parts (ferrous or

COUNTS to any length

accurately — easily!

POST Lineal Footage Counter

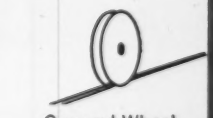


Connected to any Post Decitron electronic counter, the new lineal footage device permits accurate length measurement for continuous production items. *

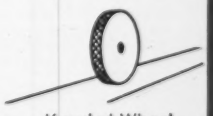
Each time the wheel revolves a photolight beam is broken and a count equal to one foot is registered by the counter. Varied "beam-hole", or wheel size will permit the counting of fractional parts of a lineal foot if desired. Different types of wheels provide traction surfaces for wire, rope, aluminum sheets, bar or flat steel, paper, cloth, etc.

Used in conjunction with a Post Decitron "preset" counter, (i.e. PW-2) a predetermined length of stock can be measured, and "marked" or cut-off as desired.

* No wheel slippage . . . *utilizes frictionless bearings.*



Grooved Wheel



Knurled Wheel

Rubber Coated Wheel

Rely on Decitron . . .
for Counting Measurement and Control

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For more information circle **68** on inquiry card.

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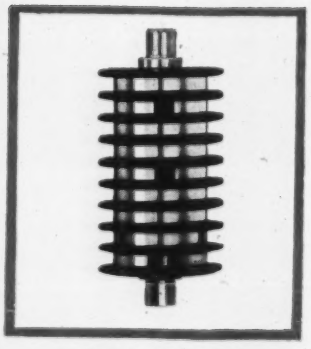

PROJECT 240E191
Commutator and Slip Ring Assembly designed and produced to meet Gov't specs., MIL-E-5400, MIL-E-5272B. Electrical tolerance (phasing) ±1° RPM 140 — Life 1000 hours min. Brush noise 3 MV max. at 0.5A. ¾" dia. rotor.

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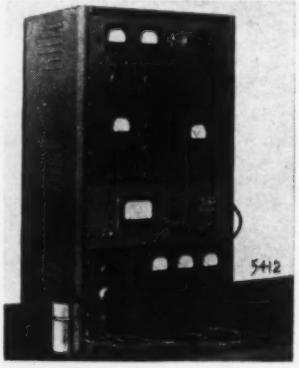
For more information circle **69** on inquiry card.

non-ferrous) which look alike but differ in analysis, hardness, case depth or other property. Method: a known and acceptable part is inserted in test coil as a "standard"; unknowns then placed in coil give same reading if they are same as standard, different reading if not. Several thousand parts per day can be sorted.—*J. W. Dice Co., 1 Engle St., Englewood, N. J.*
For more information circle **254** on inquiry card.

Gyro Tester

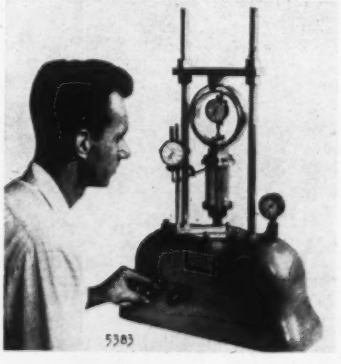
New Gyro Tester features circuit eliminating time-consuming rate table techniques; calibrates torques up to



100 dyne-cm; continuously indicates drift rate that can be recorded for long-term drift measurements; can also test for mass unbalance, reaction torque of torque generator or signal generator, and earth rate measurements; can be used for inspection, experimentation, and trouble-shooting.—*Cedar Engineering Inc., 5806 W. 36th St., Minneapolis 16, Minn.*
For more information circle **255** on inquiry card.

Soil Compression Tester

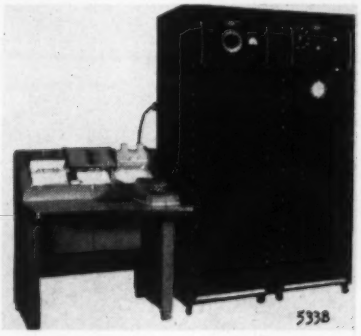
New portable "Unconfined Compression" testing machine weighs 35 lbs.; makes possible rapid job-site or lab



testing to determine stress and strain relationships of soils for foundation design and construction control. Loads to 500 lbs. are measured on a double proving ring assembly.—*Soiltest, Inc., 4711 W. North Ave., Chicago 39, Ill.*
For more information circle **256** on inquiry card.

Data Recorder for Gyro Rate Tables

New "System No. 177" makes use of magnetic techniques to punch automatically on IBM cards data arriving

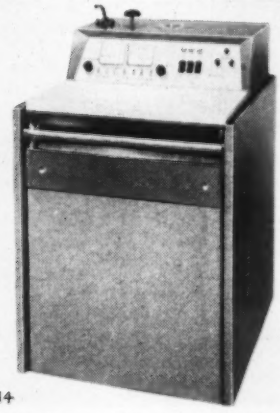


assynchronously from as many as ten separate sources. Data are time interval measurements (accurate to 0.0001 min), dates, identification numbers, shaft positions and temperature. —*Epsco, Inc.*, 588 *Commonwealth Ave., Boston* 15, *Mass.*

For more information circle **257** on inquiry card.

Leak Detector

New design of leak detector utilizing radio-frequency mass spectrometer principle; embodies plug-in chassis

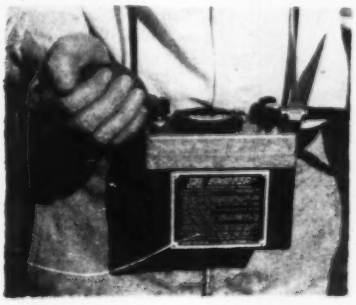


to simplify maintenance; provides audible and visible warning; measures leak rates of 1 part in 700,000.— *Beckman Division, Beckman Instruments, Inc., Fullerton* 1, *California.*

For more information circle **258** on inquiry card.

Portable Gas Detector

New "Model G Sniffer" for detecting combustible gases and vapors includes improvements, among them: (1) On-off switch has been integrated with aspirator bulb in such a way



CHATILLON

ISO-ELASTIC* TUNING FORKS

Insure constant frequencies through wide temperature variations

AMAZING ALLOY AUTOMATICALLY COMPENSATES FOR TEMPERATURE CHANGES FROM −50°F TO +150°F

Chatillon, maker of "the World's Most Accurate Spring" also produces Tuning Forks made of Iso-Elastic alloy for the Instrument and Electronic Field.

This remarkable, Chatillon developed alloy lends itself particularly to Tuning Fork applications due to its hysteresis error of less than .05% of deflection, drift not exceeding .02% of deflection in 5 minutes plus automatic compensation for temperature changes from −50°F to +150°F. Thermostatic control systems for the maintenance of constant temperatures are thus unnecessary. Chatillon Iso-Elastic Tuning Forks are used by General Electric Co., Daystrom Instrument and others.

CHATILLON makes Spiral, Torsion, Compression and Form Springs of Iso-Elastic material, as well as springs of conventional alloys.

For Formal quotation on your complete Tuning Fork specifications and quantity requirements, write or wire CHATILLON SPRING DIVISION.

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JOHN CHATILLON & SONS 85 CLIFF STREET, NEW YORK, N. Y.

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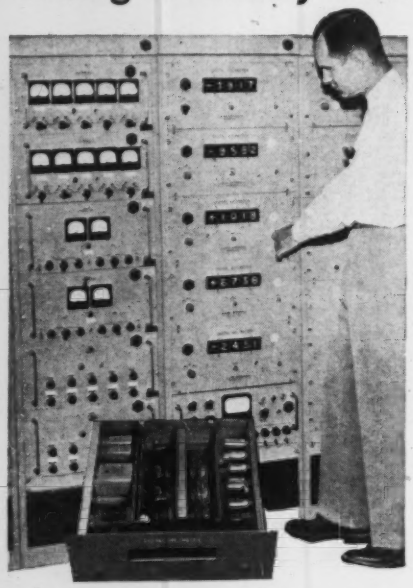
For more information circle **70** on inquiry card.

E-I Digital Voltmeters automatically digitize analog telemetry data



give Douglas engineers digital output *in real time*

The Telemetry Ground Station for the Douglas F4D Skyray monitors and records the various parameters of the aircraft during flight. The data, as recorded on magnetic tape, is then played back through the Data Reduction Station where it is plotted and digitized *in real time*.

Automatic operation

To compute in real time requires that the varying analog voltages from the aircraft be digitized. Six EI Digital Voltmeters, used in this application as analog-to-digital converters operating in real time, automatically digitize these voltages, and provide the necessary circuits for printing the data on an IBM tabulator.

Measure voltages within 0.01%

Although these particular EI instruments are special, in that they employ a unique, high-speed logic, standard EI Digital Voltmeters are now widely used for precise, automatic measurement and display of D.C. voltages. Operation is entirely automatic; no manual adjustments are required after calibration. Digital, in-line presentation eliminates reading and interpretation errors. Numerous models are available, including 3-, 4-, and 5-digit instruments. Special requirements given prompt attention. Write for catalog explaining these precision devices today.

Engineering representatives in major U. S. and Canadian cities

ELECTRO INSTRUMENTS INCORPORATED

3794 Rosecrans St., San Diego 10, California

For more information circle **71** on inquiry card.

NEW INSTRUMENTS

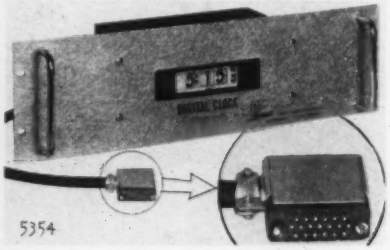
that grasping bulb to draw in a sample automatically turns indicator on; when bulb is released, instrument is shut off. (2) New type flame-arresting system permits use of an extremely soft aspirator bulb. (3) Size and weight reductions.—*Johnson-Williams, Inc.*, 2747 *Park Blvd., Palo Alto, Calif.*

For more information circle **259** on inquiry card.

TIME, SPEED and COUNT

Digital Clock

New "Model LD-1500 Digital Clock" gives both visual and electrical representation of time. Internal contact



closures for remote indication or printing provide binary coded decimal time representations of hours, ten minutes, minutes and tenth minute intervals. In addition, a contact is provided once each second for timing lines where applicable.—*Lawson Time Mfrs., 1109 S. Fremont Ave., Alhambra, Calif.*

For more information circle **260** on inquiry card.

5-60-min. Time Switch

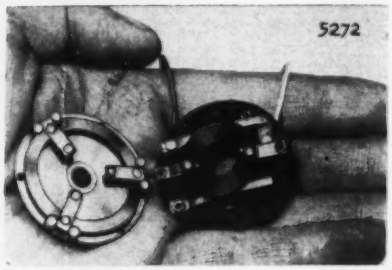
New changes in engineering, design, and manufacturing methods for "Intermatic T670 Series Time Switches"

result in more accurate timings, and a minimum variation in timing intervals. "Series T670" switches permit as many as 14 different on-off cycles a day, all on one dial and each cycle individually adjustable for timings from 5 to 60 minutes. Three contact arrangements: spst normally closed; spst normally open; spdt alternating contacts.—*International Register Co., 2624 W. Washington Blvd., Chicago 12, Ill.*

For more information circle **261** on inquiry card.

Centrifugal Switches

New high-speed "Syncro-Snap" rotary switches are said to "provide complete and instantaneous cut-in or cut-out, a characteristic never before obtainable in a centrifugal switch." Snap-type switching action is completed within 3 rpm of shaft. Units

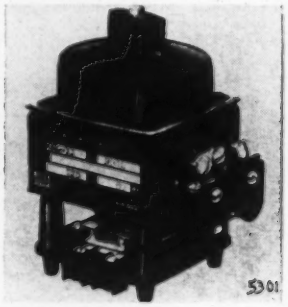


are inherently balanced and temperature compensated; can be used as overspeed or underspeed limit control, or in high-and-low pairs; are furnished for any speed to 13,000 rpm. Packaged "Syncro-Snap" speed control devices can be furnished to specifications in open, closed, or explosion-proof housings.—*Torq Engineered Products, Inc., Interstate St., Bedford, Ohio.*

For more information circle **262** on inquiry card.

Time Delay Relay

New "Model NEL" of maker's pneumatically-controlled "Agastat" features an electrical interlock in a cir-

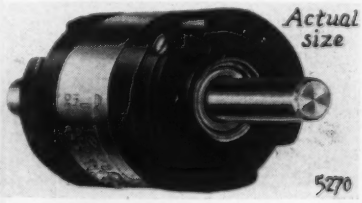


cuit which allows push button control, obtained by use of an instant-action auxiliary switch; is for operation on energization; is available for all ac and dc voltages, in sp-dt double-break and dp-dt single-break models. Rating 15 amp @ 115 vac.—*A'G'A Div., Elastic Stop Nut Corp., Elizabeth, N. J.*

For more information circle **263** on inquiry card.

Miniature Speed Reducers

New "Series 107" Miniature Speed Reducers with servo-mount ends are now available for anti-backlash applications come in 448 ratios from 1:1 to 531,441:1; have nominal 1/80 hp rating. Anti-backlash results from two



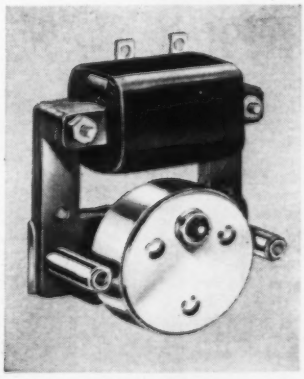
Where timing is important you'll find Telechron motors

Telechron motors are built for dependable, accurate timing!

In rubber manufacturing plants, for example, Telechron motors control the carefully calculated opening and closing of the mechanical goods press. Telechron motors also power the timers which control the mechanics of the curing cycle.

Telechron timing motors are equally essential to such widely varied industry as steel, milk, plastics (and a host of others, too). They are the choice of the instrument industry. Selected from experience as the most dependable made.

Write, wire or phone for our complete catalog and detailed information on our Application Engineering Service. Telechron Motors, Clock & Timer Department, General Electric Company, 69 Homer Avenue, Ashland, Mass.

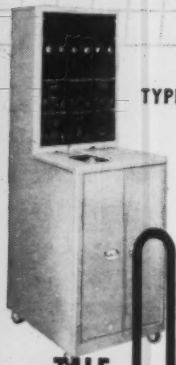


EQUIPPED WITH Telechron MOTOR

Telechron®
MARK OF TIMING LEADERSHIP

For more information circle 72 on inquiry card.

70 mm.
for
one
millivolt
yet drift-free



THE OFFNER DYNOGRAPH

0.001 volt input d-c gives 70 mm. deflection with this high-speed direct writing oscillograph, many times that for competitive units. The Dynograph with *one amplifier* is used for all types of inputs for measuring speed, temperature, position, vibration, and other variables. Patented, chopper amplifier design makes it sensitive, stable, and versatile. Available in both 6 channel console model and single and dual channel portable models. *Get bulletin L742—compare the Dynograph with all competitive models—it combines sensitivity with absolute stability.*

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5326 N. Kedzie Avenue
Chicago 25, U. S. A.

For more information circle **73** on inquiry card.

NEW INSTRUMENTS

parallel gear trains that are spring-loaded against each other.—*Metron Instrument Co., 432 Lincoln St., Denver 3, Colo.*
For more information circle **264** on inquiry card.

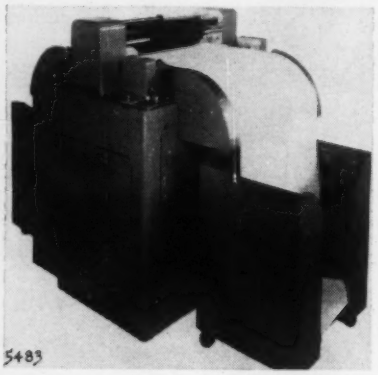
Universal Counter-timer

New "Model DS-7100" weighs 32 lbs and measures 15 x 7 x 13 in; is said to be "the first multi-purpose instrument to be offered combining both compactness and portability." Frequency ranges from 10 to 100,000 cps in time intervals of 40 usec to 100,000 sec; period range of 1 to 10,000 cycles. Temperature-compensated 100-kc. crystal oscillator circuit has a stability of 1 part per million.—*Detectron Corp., North Hollywood, Calif.*
For more information circle **265** on inquiry card.

COMPUTING and DATA-HANDLING

High-speed Reader-typer

New "Model 190 Typer" (superseding "Model 100") produces "hard copy" from output of computer or mag-tape at rates up to 108,000 characters per minute. It is of drum type, 120 columns in width, types any of 64 characters.—*Shepard Laboratories, 408 Morris Ave., Summit, N. J.*
For more information circle **266** on inquiry card.



L-f Pulse Generator

New "Model 32 Cyclic Reset Generator" (accessory to maker's "Model 30 Analog Computer") is a pulse generator of variable low frequency and low duty cycle which periodically resets computer and provides a synchronized trigger for repetitive solution presentation on 'scope screen.—*Donner Scientific Co., 2829 Seventh St., Berkeley 10, Calif.*
For more information circle **268** on inquiry card.

Computing-system Coupler

New "Intercouplers" couple National Cash Register series 3100 or 3200 Accounting Machines directly to IBM Card Punches, (Models 016, 103, 031, 024, 026, and 526,) or to 5 or 8 channel Commercial Controls Model 2 motorized tape perforators; eliminate key punching and verification of cards; assure that tabulation data are identical with posted records. Cards or tape are automatically produced while operator is posting records.—*Systematics Inc., 105 Lyndon Drive, Hermosa Beach, Calif.*
For more information circle **267** on inquiry card.

Magnetic Tapes

New "Irish Instrumentation Tape #311" permits rate of 15,000 alphabetical or numerical characters per second; is for both computer and telemetering applications. Fifty types include tapes on acetate and Mylar films in 1200, 2400, and 4800 ft lengths, and in ¼, ½, ⅝, ¾, and 1 in widths. Among features: precision slitting to microscopic tolerances; mirror-finish; tape virtually drop-out free.—*ORRadio Industries, Inc., 120 Marvyn Rd., Opelika, Ala.*
For more information circle **269** on inquiry card.

Business Computer

New "Univac File-Computer" makes possible combined billing, inventory control and sales analysis—all in a single high-speed operation. It eliminates most manual or machine steps usually required for matching up customer order data with related master descriptions, inventory balances, prices, sales-to-date totals, etc. Because of high-speed random access, no sorting, merging, collating, repro-

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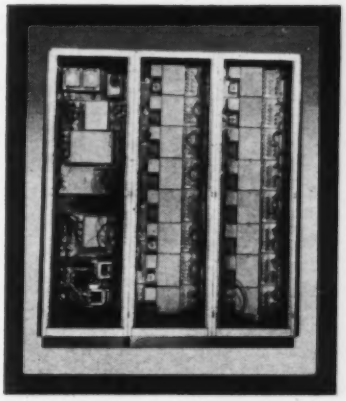
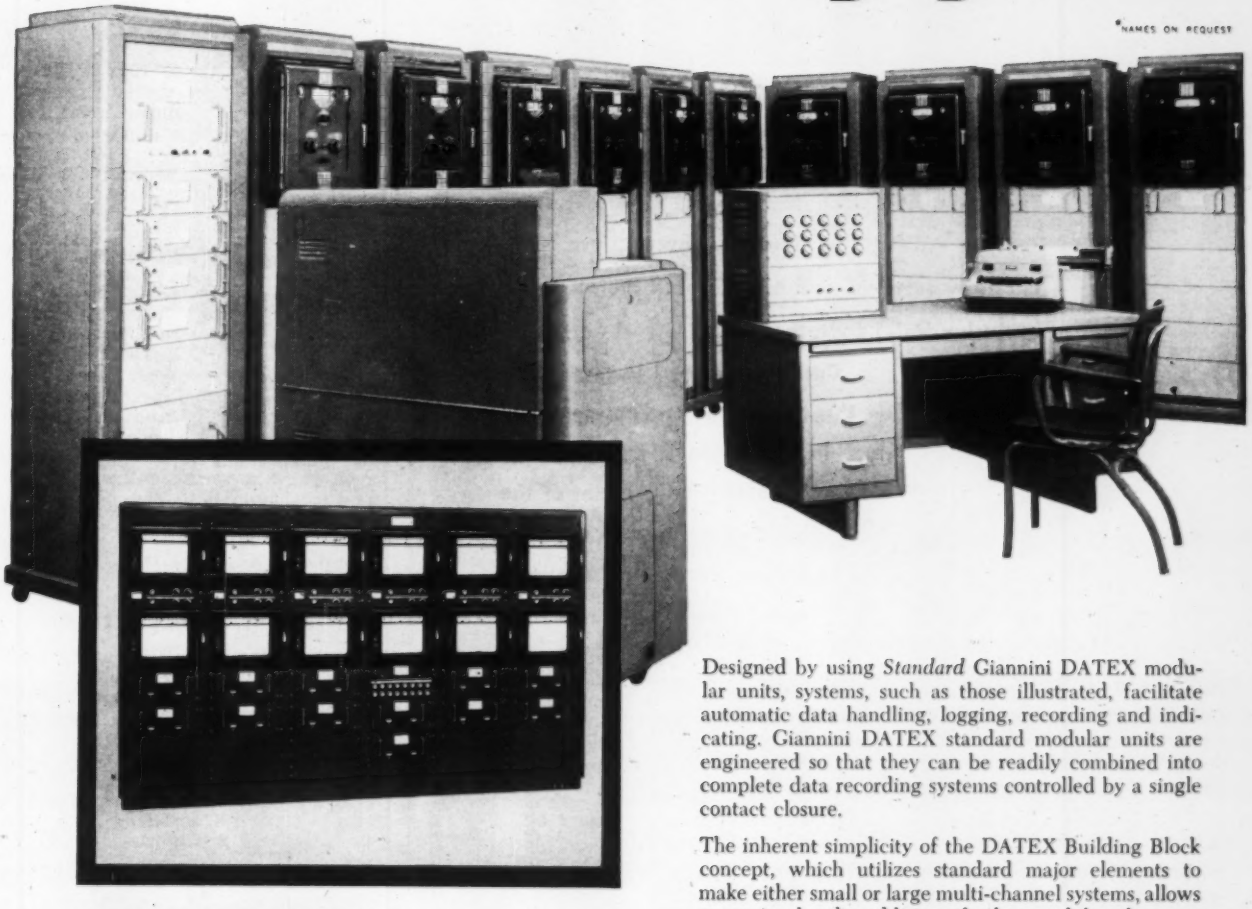
in operation!*



datex digital data recording systems

*NAMES ON REQUEST



Designed by using *Standard* Giannini DATEX modular units, systems, such as those illustrated, facilitate automatic data handling, logging, recording and indicating. Giannini DATEX standard modular units are engineered so that they can be readily combined into complete data recording systems controlled by a single contact closure.

The inherent simplicity of the DATEX Building Block concept, which utilizes standard major elements to make either small or large multi-channel systems, allows expansion by the addition of other modular elements. Various input or output arrangements are possible by using standard switching or sequencing techniques. Combinations of outputs (punch cards, typewritten tabulation, visual light bank, printed tape or punched tape) are readily obtained by the addition of proper modular units. Basically electro-mechanical in design, DATEX systems use simple tested components of proven reliability to give superior performance.

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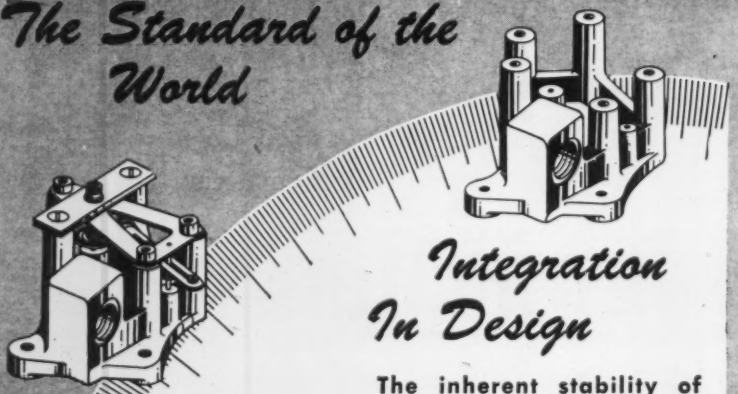
For more information circle **74** on inquiry card.

HEISE GAUGES

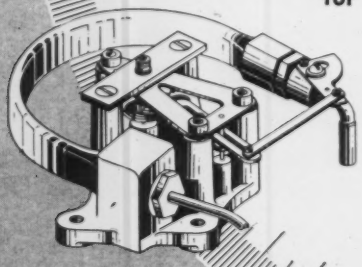
The Standard of the World

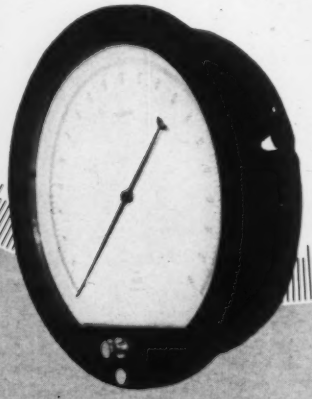


Integration In Design

The inherent stability of the Heise Gauge movement and the elimination of significant hysteresis effect in the integrally mounted Bourdon Tube give the Heise Gauge its ability to indicate faithfully the most minute pressure variations. The scientific design of the Heise Bourdon Tube section and its weldless construction from carefully selected and heat treated metals is an exclusive Heise feature.

Custom designed to meet your specific needs, this gauge will register precisely for liquids, gases or mercury. Convenient adjustment of the dial may be used to compensate for barometric changes.





Pressure Ranges
15 to 20,000 P.S.I.

DIAL SIZES
8½" — 12" — 16"

PRICES
from $151.60

DELIVERY
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BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

For more information circle **75** on inquiry card.

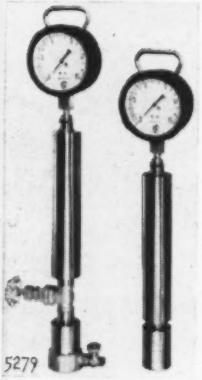
NEW INSTRUMENTS

ducing, or pulling of cards from a tub file is required before processing can begin. Example of programming versatility: use of tape input for continuous checking of inventory and sales performance simultaneously with billing: tape would contain information on each item such as sales quota and re-order point; automatic computations could be made to determine significant variations from quota and items which are approaching re-order point; each such exception would be typed out into a condensed report for executive attention. Up to 100,000 items can be processed in a day, depending on number of computations required per item.—*Remington-Rand Inc., 315 Fourth Ave., New York 10, N. Y.*

For more information circle **270** on inquiry card.

LABORATORY

Reid Bombs

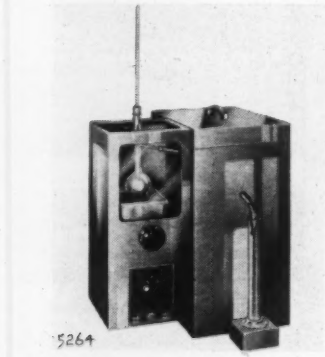


New designs of Reid Vapor Pressure Bombs for ASTM D 323 and D 1267 are especially recommended for testing blended motor fuels and LPG products, as well as for gasolines, benzol blends, etc. Both Pressure Model and Immersion Model Bombs feature easier assembly and disassembly. Gaskets now used withstand extreme temperatures (from −65 to 225°F) and resist action of vapors. A new bleeder valve and adapter assembly is available, as are seven gages covering entire range of pressures from 0 to 250 psi.—*Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.*

For more information circle **271** on inquiry card.

Distillation Apparatus

New "Clear-Vue Distillator," said to be "the first major development in distillation apparatus in fifteen



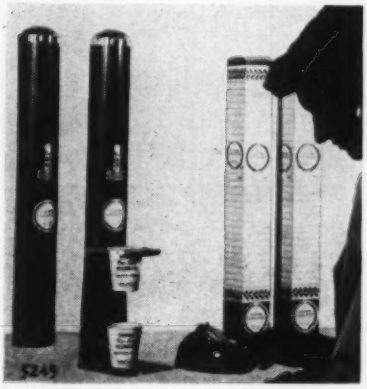
years," features a quarter-turn condenser tube which permits distillation shield to be set flush with condenser, whence unobstructed observation of

all receiving flasks. Among other features "Add-A-Unit" construction, heat-treated observation window, built-in flask height adjustment, "Powerstat" control, ice or mechanical refrigeration.—*Labline, Inc.*, 3070 *W. Grand Ave., Chicago* 22, *Ill.*

For more information circle **272** on inquiry card.

Disposable Cup Viscosimeter

New "One-shot Viscometer" consists of a disposable "orifice cup" with a metal orifice at bottom and a



disposable "receiver cup." Also supplied: metal stand for holding orifice up in position and two metal wall brackets.—*Gardner Lab., Inc.*, 4723 *Elm St., Bethesda* 14, *Md.*

For more information circle **273** on inquiry card.

ELECTRICAL TESTING EQUIPMENT

Semiconductor *N-P* Tester

New "Model JR1," for determining N or P type conductivity, is designed around a convenient thermoelectric probe constructed with spectrographically pure graphite electrodes to minimize sample contamination. Direction of galvanometer deflection reveals conductivity type of sample under test.—*Baird Associates, Inc., Dept. SN*, 33 *University Road, Cambridge* 38, *Mass.*

For more information circle **274** on inquiry card.

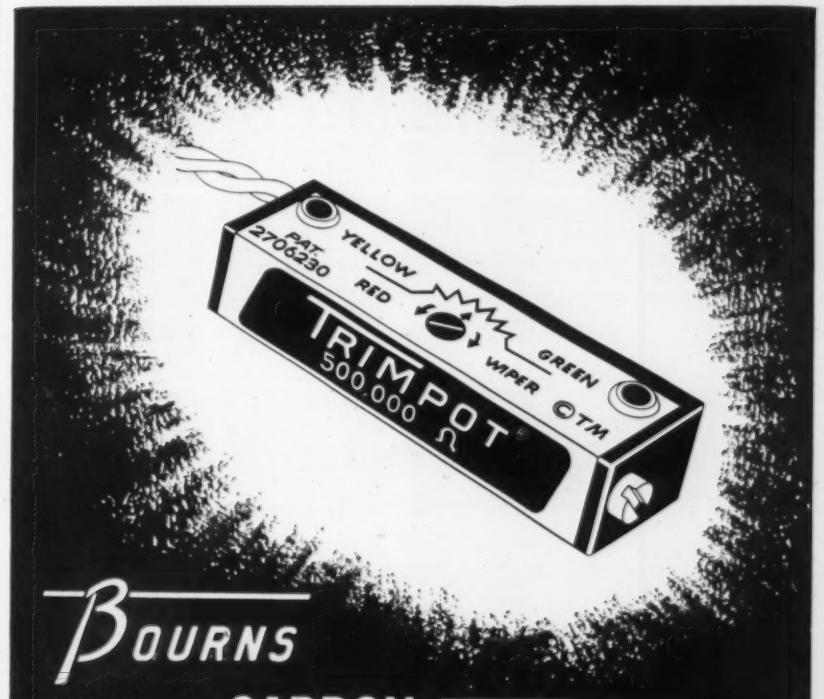
Coil-and-capacitor Tester

New "Model G-218 Magneto Coil & Condenser Tester," designed for both flywheel and multiple-cylinder magnetos, finds greatest utility in lawnmower, chain-saw, outboard-motor and related fields. Coils are tested for open circuit, shorted turns, insulation breakdown, core loss, grounds, etc. Capacitors can be checked for opens, shorts, leakage and capacitance. Tester operates from 110-vac line. Immediate shipment.—*King Electric Equipment Co., Cleveland* 5, *Ohio.*

For more information circle **275** on inquiry card.

Test Receiver

New "Type 110 Precision Test Receiver" combines a high-gain low-noise-figure 30-Mc receiver, a secondary standard of attenuation and means for testing i-f output of a wide variety of microwave mixers. When combined with a suitable local oscilla-



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new CARBON TRIMPOT®

provides···

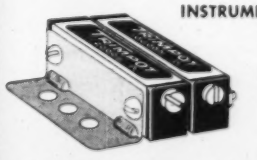
INFINITE RESOLUTION
HIGHER RESISTANCE

20,000 OHMS TO 1 MEGOHM
POWER RATING 0.2 WATT

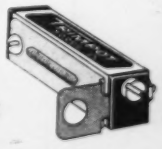
Bourns new carbon TRIMPOT is identical in size and configuration to the popular wirewound TRIMPOT which is approved as a standard component by engineers in aircraft, missile and electronic industries. Outstanding features are:

Compact size	1/4" x 5/16" x 1-1/4"
Adjustment	25-turn, self-locking
Mounting	Single or stacked with #2-56 screws
Vibration	10-20 G; 10-2,000 cps
Acceleration (steady state)	100 G
Optional features	Teflon leads, extended shaft

INSTRUMENTS SHOWN ACTUAL SIZE



MOUNTING BRACKETS AND #2-56 SCREWS CARRIED IN STOCK



Side Mounting Bracket No. 120-20-2

End Mounting Bracket No. 120-20-1

Bourns manufactures other precision potentiometers to measure Linear Motion; Gage, Absolute and Differential Pressure and Acceleration.

BOURNS LABORATORIES

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For more information circle **76** on inquiry card.

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. . . offers cost-cutting benefits in measurement and control!

Your Wheelco field engineer can serve you . . . and save for you . . . in ways that go far beyond delivery of the product. A factory-trained instrument specialist, he can help you specify and design control systems closely tailored to the job. He can assist you with installation and service problems, survey your supply requirements, and stock instruments, parts, and thermocouples needed on short notice. With a complete line of the world's finest instruments and accessories to choose from, you can buy with confidence from your Wheelco representative.

Newest instrument development for furnaces, ovens, and kilns

Wheelco's 400 Series Capacitrols bring you *two* totally new control forms for reducing cost and increasing accuracy of heating operations. Write for details in Bulletin F-6314-1.

WHEELCO INSTRUMENTS DIVISION

Barber-Colman Company

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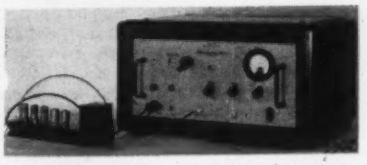
Industrial Instruments • Automatic Controls • Air Distribution Products • Aircraft Controls • Small Motors
Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

For more information circle **77** on inquiry card.

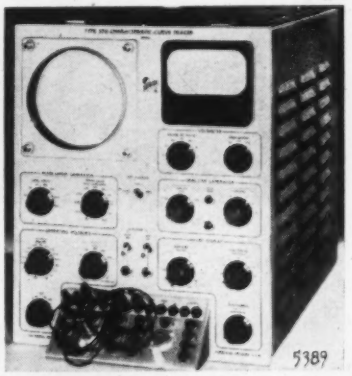


tor it becomes a sensitive detector of microwave energy. It can be used for accurate measurements of differences in r-f and i-f power levels.—*Airborne Instruments Lab., 160 Old Country Rd., Mineola, N. Y.*

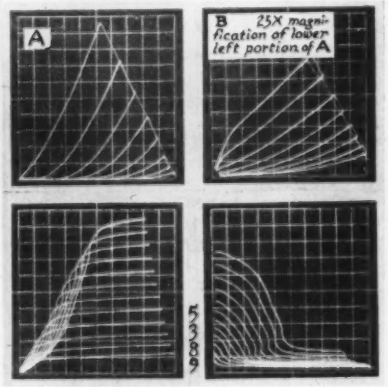
For more information circle **276** on inquiry card.

Characteristic-curve Tracer

New "Type 570" presents an accurate graphic analysis of vacuum-tube (and solid-state device) characteris-



tics under almost any conceivable operating conditions; displays families of characteristic curves on a CRT

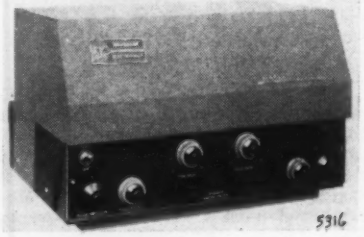


screen calibrated to permit accurate direct current and voltage readings.—*Tektronix, Inc., P. O. Box 831, Portland 7, Oregon.*

For more information circle **277** on inquiry card.

Marker-Pulser

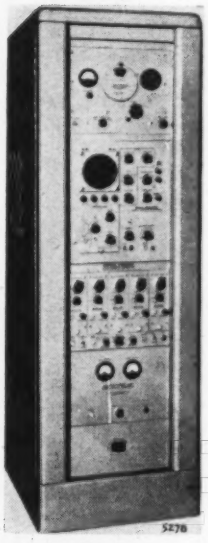
New combination marker generator and pulse generator features all outputs locked together to provide com-



pletely jitter-free synchronization of output pulses, 'scope-marker pulses, and 'scope-synchronizing pulses. Measurements of time delays in 0.01-usec increments are made rapidly by means of calibrated dial which minimizes need for operator interpolation of 'scope traces.—*Brubaker Electronics, 9151 Exposition Drive, Los Angeles 34, Calif.*

For more information circle **278** on inquiry card.

Microwave Generator

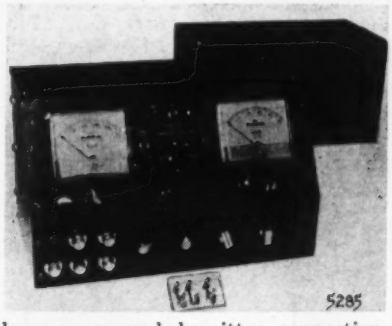


New "Model B" code-modulated microwave generator with five independently-adjustable stable pulse channels is equipped with four interchangeable RF microwave oscillator heads and features a precision oscilloscope; provides code-modulated carrier from 950 to 10,750 Mc for beacons, missiles and radar. Each pulse channel has variable pulse width and delay and also an external pulse-time modulation input. Repetition rate is variable. Built-in ac line voltage regulator insures stability; modulator is equipped with regulated low-voltage dc supply.—*Polarad Electronics Corp., 43-20 34th St., Long Island City 1, N. Y.*

For more information circle **279** on inquiry card.

Transistor Test Set

New "Model T-62" handles point contact and junction transistors, low and high power types, in grounded-



base or grounded-emitter connection. Five current bias ranges from 50 microamps to 500 milliamps full scale; 0-10 and 0-100 collector voltage bias ranges. All power supplies self-contained. No batteries. Small signal parameters h_{11}, h_{12}, h_{22}, alpha and 1-alpha, are measured at 270 cps by a powerful and stable self-contained oscillator and locked-in phase-sensitive voltmeter.—*Scientific Specialties Corp., Snow and Union Streets, Boston 35 (Brighton), Mass.*

For more information circle **280** on inquiry card.

Portable Tachometer Tester

New "Model T.T. Type M-5" is for rapid field or shop testing of aircraft electrical tachometer generators and

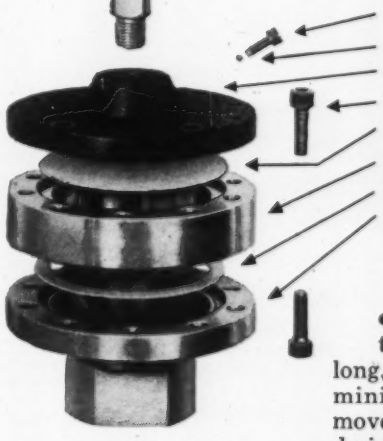
an ACCO product

Helicoid Chemical Gage

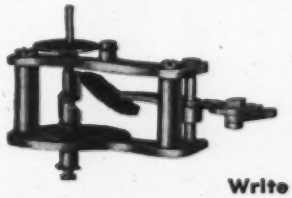
Gages for corrosive chemicals and liquids up to 5000 p.s.i.

• Here's an accurate pressure gage for chemicals and other viscous liquids which might corrode or clog the Bourdon Tube. It registers working pressures from 30″ vacuum to 5000 p.s.i. and temperatures to 400° F. Guaranteed accuracy plus or minus 1%. A single diaphragm seals off objectionable substances from the indicating gage. This gage is filled completely with specific inert liquids and pressure is transmitted directly to the indicating gage through deflection of the sealing diaphragm.

FEATURES



• HELICOID GAGES cost less in the long run because they give long, trouble-free service with a minimum of maintenance. The movement is a simple cam and roller design that does not have any gear teeth to wear out. It has been tested and proved in years of hard service.



Only Helicoid Pressure Gages Have the Helicoid Movement

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Electrical Engineering Majors will direct their activities toward devices to detect and record physical quantities such as current, emissivity, frequency magnetic flux, temperature, voltage.

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NEW INSTRUMENTS

indicators. Equipment: variable speed drive/transmission, gear box, speed booster, tac indicator, tac generator and mounting pads, adaptor, test cables, controls, calibration table, conversion table and cabinet.—*United Mfg. Co., Div. W. L. Maxson Corp., Hamden* 14, *Conn.*

For more information circle **281** on inquiry card.

Maintenance Tester

New "Model 123" weighs 12 lbs, checks line voltage to 500 vac; traces continuity with 6 v (battery) and

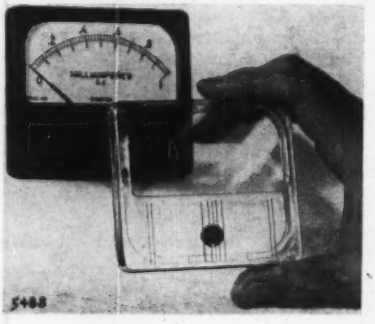
tests motor windings with 500 v for grounds or poor insulation; needs no power supply.—*Slaughter Co.,* 1700 *Nicklin Ave., Piqua* 7, *Ohio.*

For more information circle **282** on inquiry card.

ELECTRICAL INSTRUMENTS

Electrical Instruments with Colored Fronts

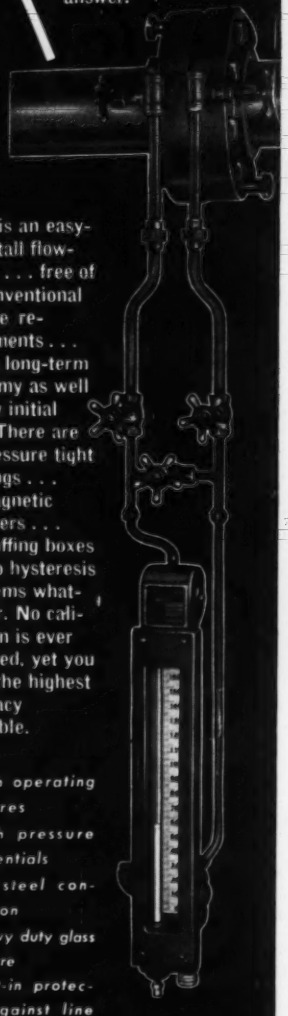
New "Model 1331" 3½-in flush rectangular instruments incorporate maker's self-shielded "Cormag" movement; have a one-piece snap-on front with zero corrector; and entire front



UNMATCHED ACCURACY

in direct flow indication

Wherever you seek simplicity and high accuracy in flow measurement at lowest cost, the Meriam "H" Meter is the well-known answer.



Here is an easy-to-install flowmeter . . . free of all conventional service requirements . . . giving long-term economy as well as low initial cost. There are no pressure tight bearings . . . no magnetic followers . . . no stuffing boxes . . . no hysteresis problems whatsoever. No calibration is ever required, yet you have the highest accuracy available.

★ High operating pressures
★ High pressure differentials
★ All steel construction
★ Heavy duty glass enclosure
★ Built-in protection against line surges

Write for Bulletin 18A

Meriam Manometer Instrumentation

...for pressures, vacuums, flows, liquid levels.

meriam

INSTRUMENT COMPANY

10920 Madison Ave. • Cleveland 2, Ohio

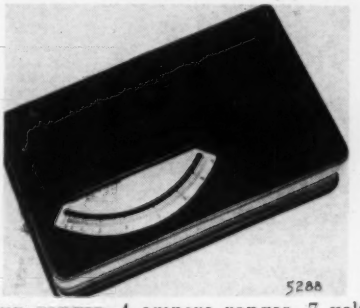
For more information circle **79** on inquiry card.

surface except for window area can be supplied in any color (or black) for quantity built-in requirements. Available as d-c and rectifier-type a-c instruments in popular ranges.—*Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.*

For more information circle **283** on inquiry card.

Laboratory Standard

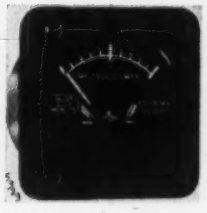
New "Model DYL" a-c dynamometer-type instrument has 12-in hand-drawn vernier mirror scale, 7 milli-



amp ranges, 4 ampere ranges, 7 volt ranges; features both electrostatic and magnetic shielding. Accuracy of 0.1% is guaranteed without time limit.—*Sensitive Research Instrument Corp., 9-11 Elm Ave., Mount Vernon, N. Y.*

For more information circle **284** on inquiry card.

Panel Instrument



New "Model 131" ruggedized 1½-in panel instrument, for aircraft or portable equipment subject to shock, vibration or temperature extremes, is available in a wide variety of scales, ranges and specifications; meets Mil-M-10304.—*Electronic Sales Div., DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.*

For more information circle **285** on inquiry card.

Panel Instrument

New 4½-in "Custom Panel Meter," said to have "many features never before found in an instrument of com-

parable size," is available in four types all housed in magnetically-shielded "unbreakable" metal cases with large scales and front zero adjustments: (1) "Custom Chrome"; (2) "Custom Chrome Illuminated"; (3) "Custom"; (4) "Custom Illuminated." These new instruments incorporate movements used in maker's "Ruggedized and Sealed Instruments"

Precision Tubeless

AIRBORNE INSTRUMENT SOURCE

STABLVOLT MODEL MRP-5-1

MRC

MRC's 5 volt instrument supply features dual magnetic amplifier regulation. Flux oscillator circuitry isolates line voltage transients from DC output voltage. Tubes and short-life components are eliminated for greatest reliability under severe operational conditions. A constant 5 VDC voltage is maintained regardless of changes in load current (0.1-1 amp.), line frequency (380-420 cps.), line voltage (95-135 volts) and temperature range (—70°F. to + 180°F.)

The Model MRP-5-1 is designed for airborne applications involving telemetering instrumentation. The Stablvolt unit components are cast in thermosetting plastic to withstand severe vibration . . . has been qualification-tested and meets MIL-E-5272-A specifications.

MICROMAG LOW-LEVEL MAGNETIC SIGNAL AMPLIFIER

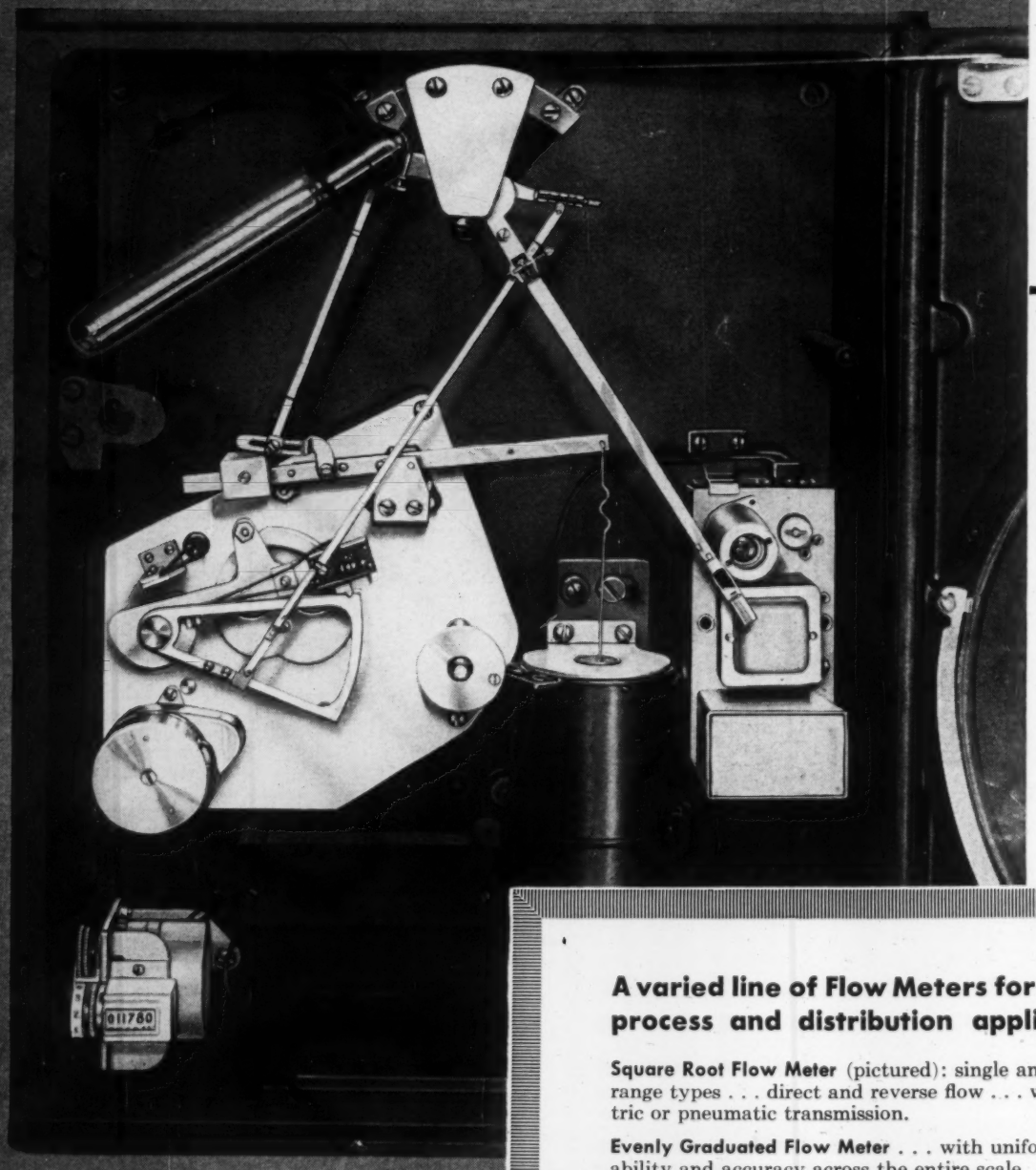
The companion Micromag serves as a reliable DC voltage amplifier (5 V output from 1 millivolt input) for telemeter systems. A drift-free, stable and a rugged performer under extreme operating conditions.

For complete technical data request MRC Engineering Bulletins EB-101 and EB-201-A.

MAGNETIC RESEARCH CORP.

200 Center Street • El Segundo, California

For more information circle **80** on inquiry card.



A varied line of Flow Meters for every process and distribution application

Square Root Flow Meter (pictured): single and double range types . . . direct and reverse flow . . . with electric or pneumatic transmission.

Evenly Graduated Flow Meter . . . with uniform readability and accuracy across the entire scale.

***ElectroniK* Flow Meter** . . . indicates, records, controls, integrates, resets control index of another instrument.

Bell Type Flow Meter . . . for low pressure gases.

Ratio Flow Controller . . . regulates secondary flow in proportion to a primary flow.

Process Sequence Controller . . . useful for timing the addition of reagent to a preset cycle.

Parshall Flume Meter . . . for measuring flow in open channels and weirs.

***Tel-O-Set* Miniature Instruments** . . . for graphic panels and other applications where space is at a premium.

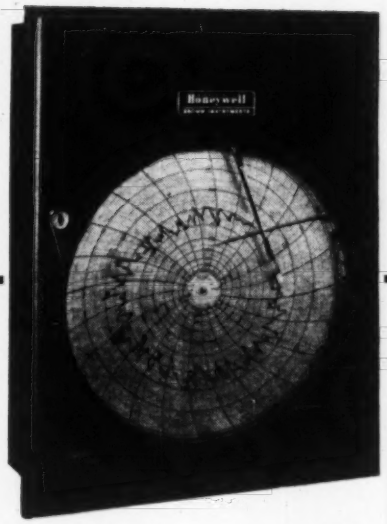
Area Flow Meter . . . electric meter body for use with viscous fluids.

Differential Converter . . . the mercuryless flow transmitter with high sensitivity, precision and rangeability.

▲ *Reference Data:*

Write for Catalog 2321, "Flow Meters, Indicating, Recording, Integrating, Controlling."

For more information circle **81** on inquiry card.



The Brown Flow Meter line

was designed for your process applications

An important reason why Brown flow meters give you better performance is that they were designed specifically for flow recording, integration and control in industrial processes. Far from being step-children of boiler plant instruments, they embody features that fit the needs of modern production technology. Their design has been refined and perfected throughout 28 years of experience in flow instrumentation . . . to assure you of the utmost in precision, versatility and reliability.

For measurement, Brown Flow Meters give you a complete range of meter bodies to work with any fluid at any pressure . . . either electrical or pneumatic transmission . . . and the flexibility of interchangeable range tubes.

For integration, Brown Flow Meters feature accurate, simple electronic flow integration, in a design that places no mechanical load on the measuring mechanism.

For control, Brown Flow Meters, particularly those with square root calibration, offer an unequalled variety of control actions to match the needs of the simplest to the most complex process requirements.

For service, Brown Flow Meters give you basically simple and rugged designs that cut maintenance to the minimum . . . plus the convenience of prompt assistance in start-ups, routine maintenance and emergencies, by Honeywell specialists located near your plant.

Ask your local Honeywell sales engineer to discuss your flow applications. He's well qualified to give competent consultation . . . and he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

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BROWN INSTRUMENTS

First in Controls

For more information circle **81** on inquiry card.

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presents

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DIAL THERMOMETERS

external calibration

Full 3½" Dial Face

- No Sector
- No Pinion
- No Linkage
- Constant Accuracy
- Easy Readability

WRITE FOR BULLETIN 350

PALMER

THERMOMETERS, INC.

Norwood Ave., Cincinnati 12, Ohio

Mfrs. of Industrial Laboratory Recording and Dial Thermometers

For more information circle **82** on inquiry card.

NEW INSTRUMENTS

except those elements which are required for extreme high-shock combat conditions.—*Phaostron Co., 151 Pasadena, Calif.*

For more information circle **286** on inquiry card.

D-c. Digital Voltmeter

New "Model 450 Digital Voltmeter" is said to provide digital readout for analog computers "at less than half

the cost of comparable previously-available instruments." It utilizes oil-immersed stepping switches life-tested for 20 million readings. Rate, one reading per second. External reference of ±100 vdc is required. Input impedance 1,000 megohms. Printer control through a 50-pin connector is standard. Models for rack mounting (illustrated) and for bench. Weight 25 lbs.—*Non-Linear Systems, Inc., Del Mar Airport, Del Mar, Calif.*

For more information circle **287** on inquiry card.

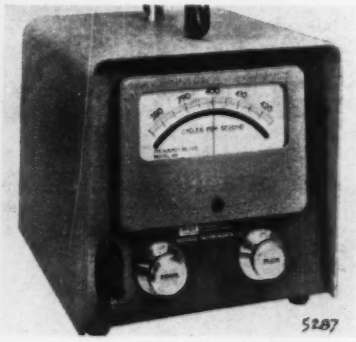
Microwave Power Meter

New "Model 430C" gives readings of microwave power levels from 0.1 to 10 milliwatts direct in decibels or milliwatts, thus obviating need of computation and adjustment during measuring. Either pulsed or cw power can be measured on either waveguide or coaxial systems. Operation of instrument is entirely automatic, and it can be used with a wide variety of bolometer mounts having either positive or negative temperature coefficients.—*Hewlett-Packard Co., 275 Page Mill Road, Palo Alto, Calif.*

For more information circle **288** on inquiry card.

Frequency Meters

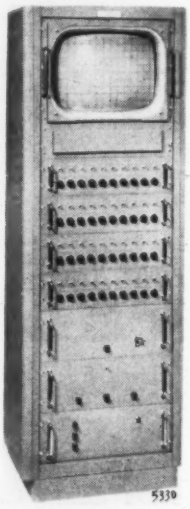
New "Model 401" (400 cps) and "Model 601" (60 cps) Expanded Scale Frequency Meters, for fast accurate monitoring of frequency, were designed originally for production tests



on motor and engine-driven generating units. Input voltage harmonics of 5%, or changes in input voltage of ±10% will not cause errors in frequency indication greater than ½ cycle for "Model 401" or ¼ cycle for "Model 601."—*Shasta Div., Beckman Instruments, Inc., P. O. Box 296, Station A, Richmond, Calif.*

For more information circle **289** on inquiry card.

40-channel Oscilloscope

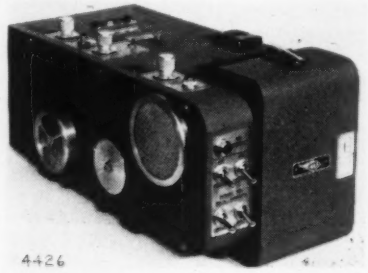


New "Large Screen Multi-Channel Display Oscilloscope" with 40 input channels features 9 x 12-in grid on a 17-in CRT. Each vertical line terminates in a dot to permit rapid and accurate reading. Output of each of the 40 amplifiers is scanned each ¼ sec; vertical length of each line indicates peak value of the maximum ac input voltage which existed during previous ¼ sec.—*Electromec, Inc., 5121 San Fernando Road, Los Angeles 39, Calif.*

For more information circle **290** on inquiry card.

Oscillograph

New "Model 581," announced as "the smallest complete flight-test oscillograph available today," features

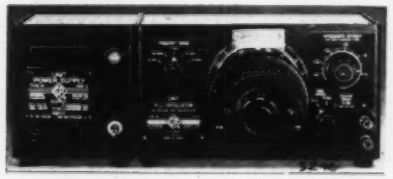


automatic record-numbering, automatic length control resettable by remote control, full-width timing lines at 0.01 and 0.1 sec, wide selection of paper speeds.—*Midwestern Instruments, 3401 S. Harvard, Tulsa, Okla.*

For more information circle **291** on inquiry card.

R-C Oscillator

New "Type 1210-B Unit R-C Oscillator" offers two new features: (1) Square-wave output over entire frequency range from 20 cps to 500 kc in addition to two sine-wave outputs. (2) Automatic recording of frequency characteristics made possible by gear-



AUTOMATIC . . . pinpoints type and location of all kinds of errors . . . *automatically.*

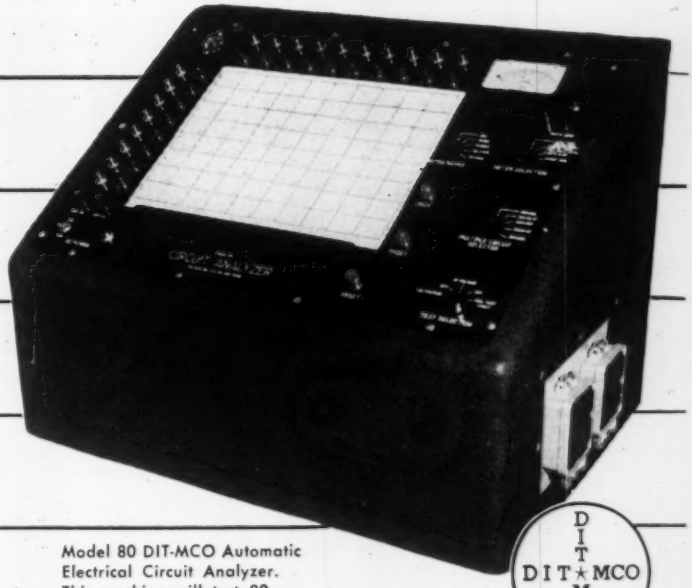
VERSATILE . . . tests any cabling system or panel assembly without modification.

UNIVERSAL . . . tests for all types of errors resulting from incorrect connections, short resistance, and insulation resistance.

SIMPLE . . . ordinary, non-technical personnel can master its operation in thirty minutes or less.

ACCURATE . . . detects and measures resistance impossible to find with most equipment.

FAST . . . checks circuits in 1/10 second each. Makes tests in minutes which once required hours.



Model 80 DIT-MCO Automatic Electrical Circuit Analyzer. This machine will test 80 circuits in 8 seconds.

NOW! A High-Speed Circuit Analyzer So Accurate It Can Detect Continuity Resistance Down to 1/10 Ohm!

DIT-MCO Automatic Electrical Circuit Analyzers

Save Time and Money in Production, Maintenance and Overhaul of Aircraft, Guided Missiles, Telephone Systems, Computers and Radar . . . Wherever Complex, Multiple Circuitry is Used!

Here is the first real solution to the production and maintenance bottleneck of testing out complex electrical circuitry. The DIT-MCO Automatic Electrical Circuit Analyzer makes all other circuit testing methods obsolete.

Where present hand and machine testers are laborious and complicated, the DIT-MCO Analyzer is fast and simple. DIT-MCO's exclusive matrix chart pinpoints errors without reference to manuals or diagrams. Non-technical personnel can easily spot the location and nature of errors on a front matrix panel, and go directly to the trouble spot for correction.

The DIT-MCO Analyzer is wonderfully versatile. It can be moved from one circuit testing job to another without modification. To prepare for a new test the operator merely plugs in a simple, straight forward adapter cable. The machine itself requires no changes at all to test any electrical cable system at any stage of production, modification, or maintenance. This even includes circuits connected together in various ways by switches, relay contacts, or a common point at a terminal such as a grounding lug. The circuits in the unit under test can be rearranged by switching mechanisms in the unit, and the tester will automatically test the new arrangement. The analyzer can functionally test external devices like relays, solenoids, actuators, and panel lights.

The almost unbelievable accuracy of this new tester eliminates hit-or-miss testing for continuity or short resistance. Unlike meters, lights, or buzzers, the DIT-MCO Analyzer defines these errors with absolute accuracy. Continuity is closely defined with this test equipment to the point of rejecting ½ ohm continuity resistance as an open circuit at currents up to 2 amperes. Leakage resistance is closely defined to the point of rejecting zero ohms to 200 megohms as a direct short. These values are pre-set as desired.

In spite of its hairline accuracy and its ability to make fine measurements, the DIT-MCO Circuit Analyzer is a rugged, practically foolproof machine. Its component parts are the same as those used for years on automatic telephone systems, and most parts are pluggable. In laboratory tests, production line machines have been kept in operation for the equivalent of 10 years with no breakdowns at all.

The tremendous speed and accuracy of this machine plus its adaptability and capacity to test for all kinds of errors, make it a "must" for companies which manufacture, maintain, or overhaul products which include complex electrical circuitry. Basic sizes are built to test 80 to 200 circuits with multiplier sections to provide as much as 1600 circuits capacity.

Write today for full details, and arrange for a free demonstration in your plant.

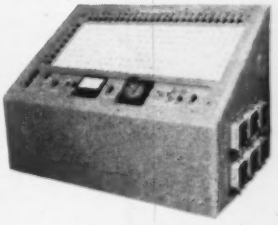
ELECTRONICS DIVISION • DIT-MCO, INC.

(pronounced DIT-MA-CO) • 507 West Ninth Street • Kansas City, Missouri

There's a DIT-MCO Analyzer To Fit YOUR Requirements!

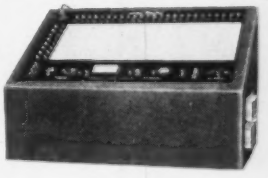
DIT-MCO Functional Tester

A universal, automatic tester for complex relay systems in all types of aircraft and guided missiles.



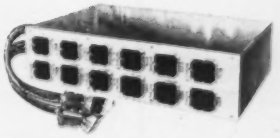
Model 200 Circuit Analyzer

Capacity: 200 circuits in 20 seconds.



Multiplier Sections

Increase capacity of Model 200 to as many as 1600 circuits.



These machines are being used by nearly every major airplane manufacturer in the United States.

INFORMATION ON REQUEST

For more information circle **83** on inquiry card.

drive precision dial arranged so that it is easily driven automatically by a "Type 908-P Synchronous Dial Drive" which can sweep any portion of each of the 5-decade frequency ranges.—*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

For more information circle **292** on inquiry card.

Radio-frequency Bridge

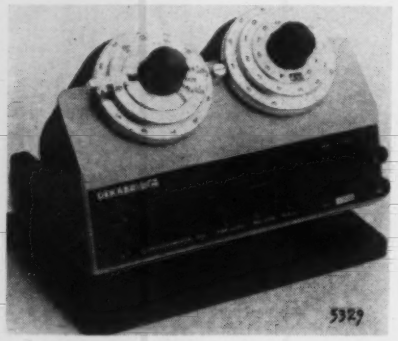
New "Type 1606-A" retains all desirable features of older "Type 916-A" and adds several new ones to increase ease and convenience of operation. Chief improvement is new broadband bridge transformer which efficiently covers entire bridge range from below 400 kc to 60 Mc. New low-loss milled-plate variable air capacitors are used as reactance standards. Resistance range 0 to 1000 ohms; reactance range ±5000 ohms at 1 Mc, varying inversely as frequency. Scale length of reactance dial doubled.—*General Radio Co., Cambridge 39, Mass.*

For more information circle **294** on inquiry card.

ELECTRICAL-INSTRUMENT ACCESSORIES

Uniline-readout Bridge

New "Model 210 Dekabridge" embodies familiar Wheatstone Bridge circuit but utilizes a dual set of maker's "Dekadials" to provide uniline readouts to four places over resistance range from zero to 12 megohms. Limit of measurement error on all ranges is 0.1%.—*Electro-Measurements, Inc., 4312 S.E. Stark St., Portland 13, Ore.*



For more information circle **293** on inquiry card.

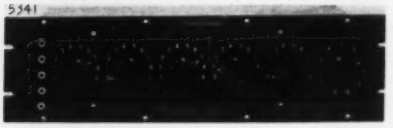
Twelve-foot Slidewire in Four-inch Box

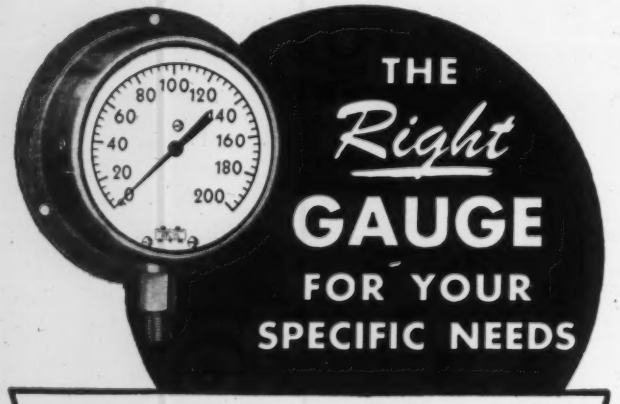
New "Ta'Pot Precision Potentiometer" is a 144-in slide-wire with direct calibration in either linear or nonlinear functions. Direct reading obviates scale-reading errors; simplifies equipment operation. Essential element is a white vulcanized fibre tape with a resistance element bonded to its edge. After assembly, it is calibrated as required, for thermocouples, strain gages, etc., as well as direct readings in resistance values. Accuracy within 0.1%; available in resistances from 75 to 30,000 ohms; power dissipation 2 watts.—*Howell Instrument Co., 1106 Norwood, Fort Worth 7, Texas.*

For more information circle **295** on inquiry card.

Standard Ratio Transformers

Four new ruggedized versions of Standard Ratio Transformers have been added to maker's line of precision ac voltage dividers. Accuracies as good as 0.005% and resolution as good as 0.00001%. Models are available to cover frequencies from 30 to





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For more information circle **86** on inquiry card.

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For more information circle **87** on inquiry card.

BORG MICRODIAL

DIRECT READING THROUGH 3600° TO A DIGITAL ACCURACY OF 1 PART IN 1000.

FITS ANY MULTI-TURN DEVICE HAND OR SERVO OPERATED

The new direct reading Borg Microdial Model 1301 practically eliminates human error because it was designed for forced fast reading. Laboratory, production and processing controls become more accurate when clear, sharp, figures on the specially designed Borg Counter are observed through the focal-point window. Borg Counter figures are seen against a dull black background to provide maximum contrast for instant perception under difficult reading conditions.

The specially designed Borg Counter in the Model 1301 Borg Microdial reads from 000 to 999 to 000 in 3600 degrees of continuous rotation with no stops. Maximum recommended operating speed is 10,000 counts per minute (100 rpm).

Designed for military application, it has a built-in dust shield and clear-vision, wide-angle window for accurate reading from almost any position in front of the dial.

The Model 1301 Borg Microdial is compact. It measures only 1-3/4" in diameter and 1-5/8" in height and occupies no more panel space than the Micropot it controls.

WRITE FOR CATALOG SHEET BED-A31

BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

For more information circle **88** on inquiry card.

NEW — UNIVERSAL CABINET RACKS

PAR-METAL ELECTRONIC HOUSINGS

Sure cure for "custom" blues!

You get "custom quality" at "standard" cost.

Expedite the production of your equipment by specifying PAR-METAL *"Universal Cabinet Racks."* Made in STANDARDIZED UNITS, these Racks give you the custom-quality you want at a price you can afford. On-schedule deliveries are assured.

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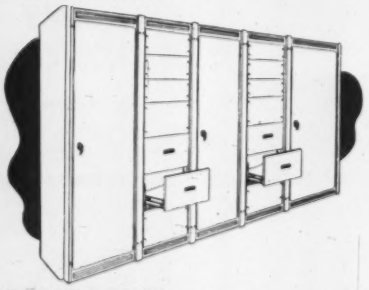
PAR-METAL *"Universal Cabinet Racks"* are made in the following dimensions:

Heights: 48⅛", 67⅜", 76⅛", and 83⅛".
Depths: 18" and 24".
Panel Widths: 19" and 24".

The Racks may be furnished with or without *front doors*, with or without *detachable side panels*, and may be used singly or in rows.

Built for Dependable Service

While incorporating new features of versatile assembly, there has been no sacrifice of *structural rigidity*. All PAR-METAL RACKS are *substantially welded* and *reinforced* for diversified industrial use.



"MULTI-RACKS": The drawing shows how you can intermix Racks of equal height, although both 19" and 24" wide panels are used, to produce a uniform-looking installation.

STANDARD ACCESSORIES: Vertical Side Supports, Sliding Shelves, Rack Mounting Chasses, Bases, Roller Trucks, etc. are available as standard equipment.

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For more information circle **89** on inquiry card.

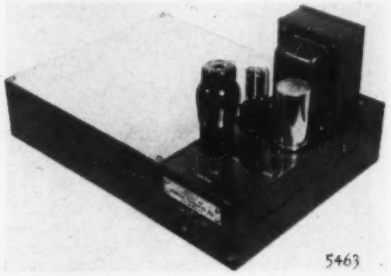
NEW INSTRUMENTS

3,000 cps (to 10,000 cps at reduced accuracy).—*Gertsch Products, Inc.*, 11846 *Mississippi Ave., Los Angeles 25, Calif.*

For more information circle **296** on inquiry card.

Chassis and Supply

New "Circuitron," said to be "the ideal foundation unit for all experimental electronic circuits," ends hodge-podge wiring, dangerous ex-



posed load resistors and inaccurate "in-line" breadboard techniques. It consists of a 14 x 10 x 3 in steel chassis with a removable aluminum top plate and a built-in electronically-regulated power supply.—*Morrow Products, Inc.*, 3339 *Forbes St., Pittsburgh 13, Pa.*

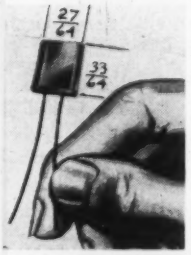
For more information circle **297** on inquiry card.

Frequency Crystal Unit

New "Thermystal" represents integrated packaging of vacuum-enclosed crystal and oven to provide high stability and extreme environmental control at economical price. Calibration accuracy: 1 cycle 0.0001%. Temperature stability better than 0.0001%; oven temperature varies less than 1 C° over ambient range of –55°C to 85°C. Secular stability better than 0.001% per year. —*James Knights Co., Sandwich, Ill.*

For more information circle **298** on inquiry card.

Miniature Crystal

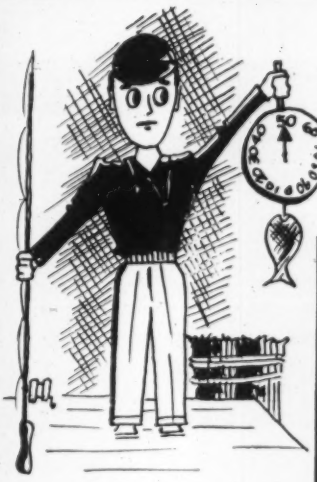


New "Miniature Overtone" easy-to-mount miniature crystal is said to give same quality performance as do much larger units. Frequency range 15 to 100 Mc; wide operating temperature range; same tolerances as larger units such as MIL CR-18, MIL CR-23, and CR-32.—*Keystone Electronics Co.*, 114 *Manhattan St., Stamford, Conn.*

For more information circle **299** on inquiry card.

Direct-coupled Amplifier

New "Model CA-401 Current Amplifier" for driving galvanometer oscillograph elements and other low-im-



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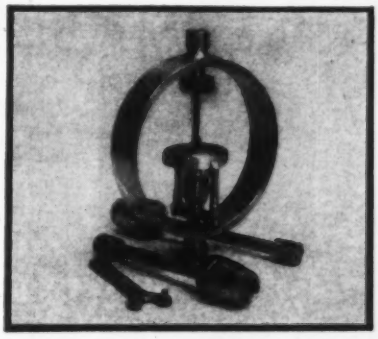

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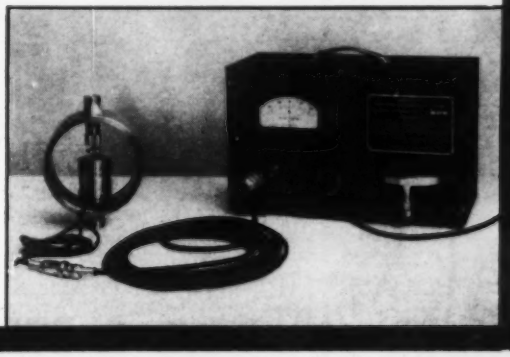

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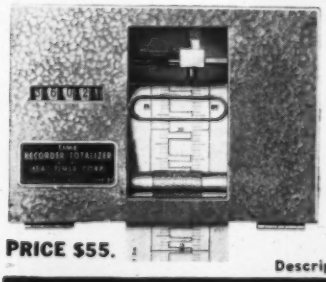

- This precision instrument provides accurate, permanent, chronological data about any machine, process or system in plant or office ...on a continuous chart-roll which lasts four months. Uses no ink. Totalizer shows accumulated "on" time.

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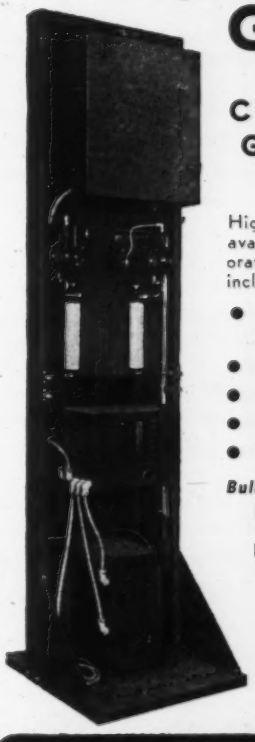

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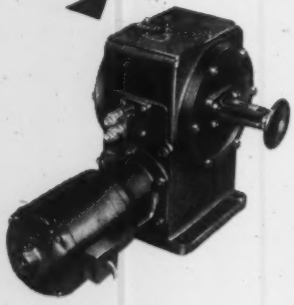
For more information circle **92** on inquiry card.

A portion of the 200 acre scale model of the Mississippi Basin, shows one of the Askania Controls used in this flood control study.

Huge 200 acre experiment needs PRECISE CONTROL!



The Askania Unit Regulator, a completely self-contained automatic control. This versatile unit, one of an extensive line, finds its widest use in applications where measured signals are low level and power requirements at the point of control are moderate.

The Corps of Engineers, U. S. Army uses a 200 acre scale model of the Mississippi Basin in flood control studies that may eventually solve that area's flood control problem. In the studies, six standard Askania Controllers were used to assist in precisely simulating the behavior of one of the world's mightiest river systems.

While flood control may not be your problem, precise, sensitive, and powerful Askania controls may be the solution to your control problems. These units are currently solving problems in the metal, glass, plastic, rubber, textile and paper processing industries. If you have control problems that are boosting your costs or lowering your product quality, investigate these Askania Controllers.

Write for Bulletins 139 and 155.

ASKANIA REGULATOR COMPANY
290 E. Ontario Street, Chicago 11, Illinois
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For more information circle **93** on inquiry card.

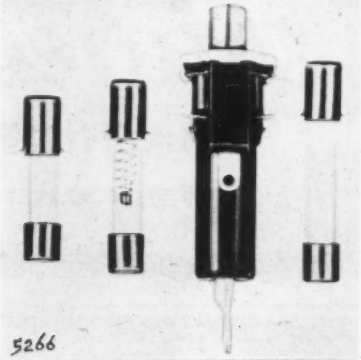
NEW INSTRUMENTS

pedance loads features full-scale output of ±40 ma into a 35-ohm load with ±600 mv input, output impedance loads from 0 to 1,000 ohms, flat frequency response from 0 to 50,000 cps.—*Photocon Research Products, 421 N. Foothill Blvd., Pasadena, Calif.*

For more information circle **300** on inquiry card.

Fuses and Holders

New "LC" fuses, said to represent "a radically new approach to circuit protection which eliminates the pos-



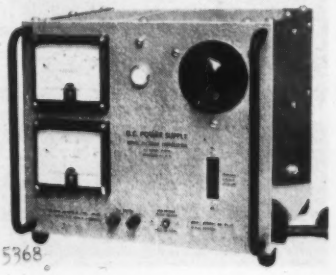
sibility of over-fusing," are made in a combination of three lengths and seven widths of bayonet-locking tabs on fuse caps. Fuse post is made to accept only the size amperage range and type (regular or "slo blo") in its range. Holder, molded from high-strength Bakelite, snaps into a predetermined chassis mounting hole and locks into place by means of a snap-in lock washer. Bayonet-type cap of fuse locks into holder, permits easy and quick insertion and removal of fuses. —*Littelfuse, Inc., 1865 Miner St., Des Plaines, Ill.*

For more information circle **301** on inquiry card.

POWER SUPPLIES

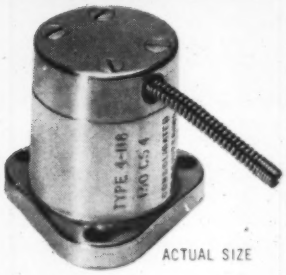
Rectifier-type Supplies

New "Powerunit" high-current dc power supplies are available in 10 models; ratings from 0-90 volts at 9



CEC Type 4-118 VIBRATION PICKUP

Designed for Accuracy at High Temperatures



Now, new hermetic sealing and a special Inconel spring suspension assure long, accurate life to this miniature, self-generating vibration pickup. It weighs *less than 1.5 ounces*, is ideal for vibration analysis where the temperature is high, space is limited, and the weight of larger pickups cannot be tolerated.

Sensitivity	105 mv/in/sec ±5% @ 250 cps, 100°F, into 50,000-ohm load
Frequency Response	Flat ±10% of 250-cps response @ 100°F from 50 to 500 cps for peak accelerations greater than 1 g.
Maximum Amplitude	0.12 in. double amplitude
Useful Temp. Range	−65° to +500°F
Damping	Magnetic
Natural Frequency	30 cps
Size, Weight	0.96" high x 0.8" diameter; 1.435 oz. with cable

Send for pickup bulletin CEC1535B-X3

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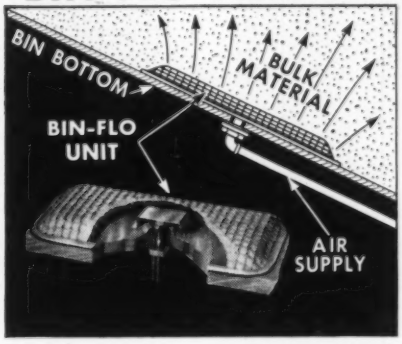
ELECTRONIC INSTRUMENTS FOR MEASUREMENT AND CONTROL

300 North Sierra Madre Villa, Pasadena 15, California

For more information circle **94** on inquiry card.

BIN-FLO AERATING UNIT

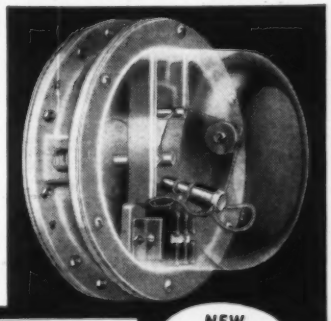


Provides Steady Flow of Dry, Finely Ground Materials which tend to bridge in storage. Uses only small amount low-pressure air.

BIN-DICATOR BIN LEVEL INDICATOR

For All Bulk Materials

signals change in level; automatically starts and stops filling and emptying equipment.



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amps to 0-15 volts at 50 amps. Full wave selenium and germanium rectifiers are filtered to 0.03% ripple on some units.—*Model Rectifier Corp., 557 Rogers Ave., Brooklyn 25, N. Y.*

For more information circle **302** on inquiry card.

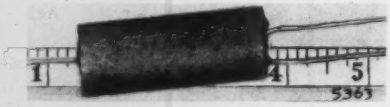
High-resolution Supply

New "Model 406" is designed expressly for instrument calibration. Coarse, fine, and vernier output controls permit setting output to within 2 mv of desired value over entire 530-v range. Regulation against 20% line voltage change or 100 ma load change is 0.01% or 50 mv. Auxiliary outputs are 0-225 v bias and 6.3 v 3 amp ac.—*John Fluke Mfg. Co., Inc., 1111 W. Nickerson St., Seattle 99, Wash.*

For more information circle **303** on inquiry card.

Miniature Power Supply

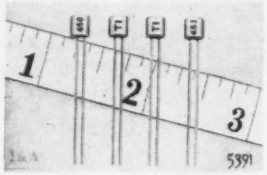
New "RB 20," believed to be "the smallest regulated power supply ever offered commercially," is intended primarily as a source of bias voltage, and for plate-to-grid coupling in amplifiers. Unusual feature is ability to utilize alternating or direct voltage power source. Temperature change



ELECTRICAL and ELECTRONIC COMPONENTS

Silicon Diodes

Four new types of silicon diodes, "650, 651, 652 and 653," for extremely accurate voltage reference, have re-

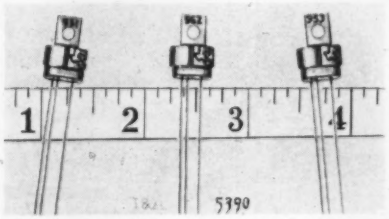


verse breakdown voltage (measured at 5 ma), ranging from 3.7 to 8.0; feature extremely small breakdown voltage temperature coefficients from –55°C to 150°C. Total power dissipation 150 mw at 25°C and 40 mw at ambient of 150°C. Maximum average rectified forward current 90 to 125 ma at 25°C; maximum reverse current 0.1 microamp at –1 v at 25°C.—*Texas Instruments Inc., 6000 Lemmon Ave., Dallas, Texas.*

For more information circle **305** on inquiry card.

Silicon Transistors

New "Types 951, 952, 953" medium-power silicon transistors are improvements on superseded "Type X-15";



can produce a power gain of 30 db, supply up to 1 watt of Class B power, and be operated up to 150°C (302 F).—*Texas Instruments Inc., 6000 Lemmon Ave., Dallas 9, Texas.*

For more information circle **306** on inquiry card.

Junction Transistors

New "2N77" and "2N105" are alloy-junction transistors of germanium *p-n-p* type designed especially for low-power a-f amplifier service; are hermetically sealed in insulated metal en-

ADJUST-ANGLE THERMOMETERS

for every conceivable use

Solve your temperature indication problems with one of Weksler's easy-to-read ADJUST-ANGLE thermometers. Available in three case styles and in scale sizes from 4½ to 12 inches, these versatile instruments position any angle through 180° arc, back or front, right or left; even after installation!

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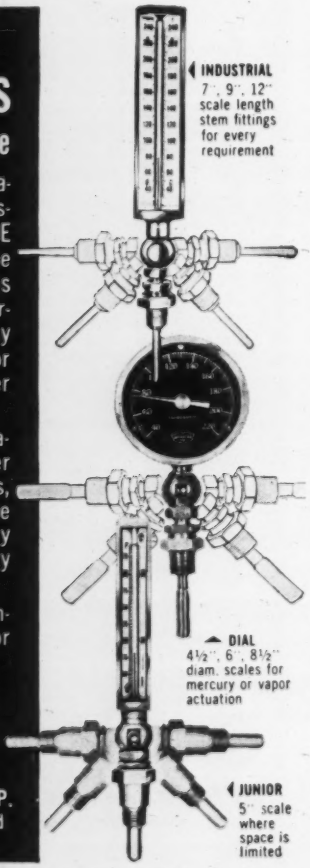
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velopes. Small size of "2N105" permits design of miniaturized equipment. ★ New "2N109" is an alloy-junction transistor of *p-n-p* type for use in class B push-pull power-output stages of battery-operated receivers and audio amplifiers operating at power levels of approx. 100 milliwatts. All three feature extreme stability and excellent uniformity of characteristics.—*Tube Div., RCA, Harrison, N. J.*

For more information circle **307** on inquiry card.

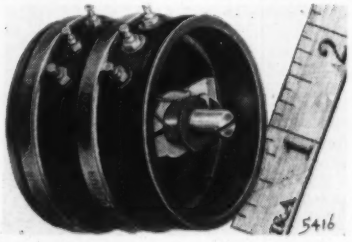
850-w Silicon Diode

New silicon diode, though almost as small as a mounting nut on an 850-watt selenium rectifier, converts an equal amount of power and outperforms its larger predecessor in every way: it converts 5 to 15 amps of ac to dc at up to 371°F without aging and at efficiency levels greater than 96% of theoretical values. This permits reduced power supply capacity, lower voltage drop and heat dissipation from rectifiers—all weight-saving, space-saving and operating-cost saving—as well as indefinite life.—*Raytheon Mfg. Co., Waltham 54, Mass.*

For more information circle **308** on inquiry card.

High-resolution VDRs

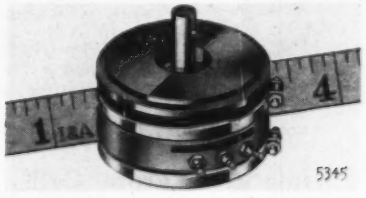
New "Series K-200 Precision Potentiometers," for low-torque high-function-angle applications, feature ball-bearings and Kohlrausch winding; ganging arrangement by one-piece clamp rings permits precise phasing of each unit.—*DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.*



For more information circle **309** on inquiry card.

Continuous-rotation VDR

New Series Y Helipot" is a single-turn continuous-rotation component designed for servo or bushing mounting. Standard linearity is 0.5%. As many as 14 sections may be ganged on a common shaft during manufacture, with as many as 17 taps added to any section. Operating range –55°C to 80°C; rating is 3.4 watts at 25°C, 2.5 watts at 40°C.—*Helipot Corp., 916 Meridian Ave., South Pasadena, Calif.*



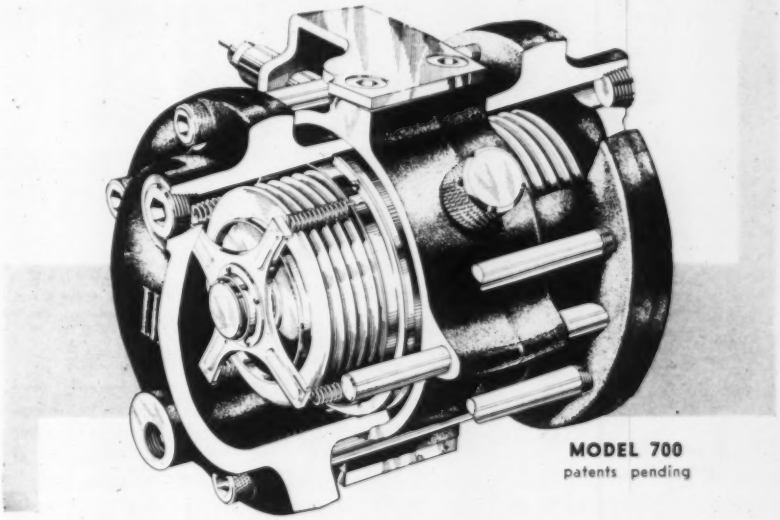
For more information circle **310** on inquiry card.

High-resistance VDRs

New "Acepot" precision wire-wound subminiature voltage-dividing resistors are available in resistance values

PROVED SUPERIOR

by major companies enthusiastically placing repeat orders



MODEL 700
patents pending

Major companies throughout the world have tried the I. I. C. bellows-type flow meter. In their own exhaustive tests they have found it far superior in performance and construction.

The I. I. C. flow meter is a combination of the most modern engineering features:

Seamless bellows—choice of either type 316 stainless steel or Monel.
Exclusive free-floating, non-freezing bearing designed and engineered by I. I. C.

Forged housings—either alloy steel or 316 stainless.

More powerful, this meter gives quicker response and more accurate recording. Pulsation dampener is externally adjustable under pressure. Compensation is provided for ambient temperatures. Affords over-range protection up to housing rating. Working pressures 1,000, 2,500, 5,000 p.s.i., furnished in all standard ranges up to 500 inches of water.

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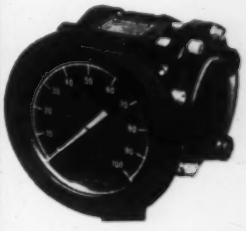
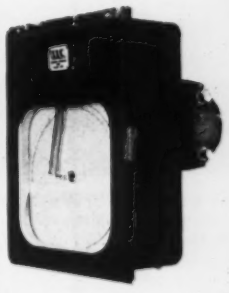
(Patents Pending)



Model 800-6 Indicator
(Patents Pending)



Model 802 Recorder
(Patents Pending)

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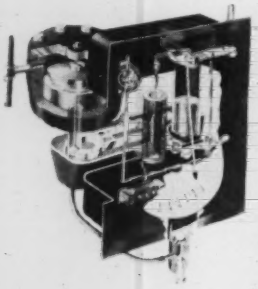
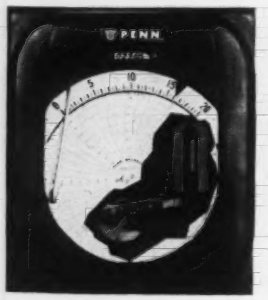
For more information circle **97** on inquiry card.

MASS

FLOW MEASUREMENT WITHOUT CALCULATION

Continuous correction for pressure or temperature variation—or both—is now available with Penn meters. A wide variety of meters permits mass flow readings to be made directly without calculations for indicated or recorded flow rates or for totalized flow.

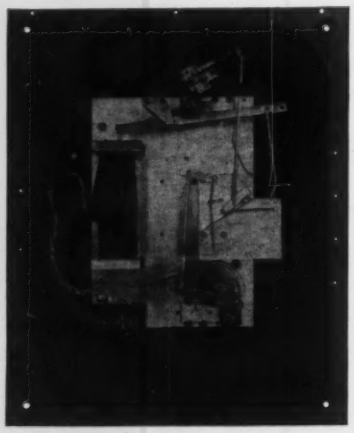




Penn mechanically compensated flow transmitter with electric or electronic receiver. For ranges of correction up to 4:1.

The famous Magna-Clutch magnetic coupling transmits the float position to the compensating mechanism. This transmitter has a wide range of applications where the total correction ratio required does not exceed 4:1.

For ranges of correction as high as 10:1, Penn features an electrical compensator that makes use of logarithmically wound potentiometers that multiply the indicated flow rate by the correction factor.



Compensation computer for combined pressure and temperature ranges of correction as high as 10:1.

Both mechanical and electrical compensators feature a stable zero. All Penn compensated flow meters are carefully designed to prevent movement in the meter mechanism resulting from variations in static pressure or temperature at zero flow. The meter will record real flow only.

PENN'S broad line of compensated flow meters offers a practical solution to a great variety of problems in the field of "mass" flow measurement. Whether the application calls for pressure, temperature, or combined compensation; whether the range of compensation required is wide or narrow, there is a PENN compensated meter which provides the logical and economical solution to the problem.

Write us today about your flow measurement problems

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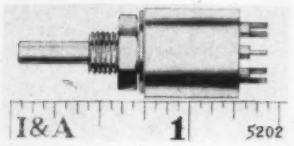
For more information circle **98** on inquiry card.

NEW INSTRUMENTS

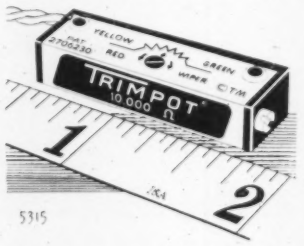


up to 100,000 ohms. It is said that this high resistance has never before been attained in subminiature units. Linearity 0.3%; ambient temperature –55°C to 125°C; power rating 2 watts for 60C° rise; torque 0.035 oz-in @ 20°C. Available in standard, servo or flush mountings; dual or up to 6-gang units.—*Ace Electronics Associates, 125 Rogers Ave., Somerville 44, Mass.*

For more information circle **311** on inquiry card.

Trimming VDR

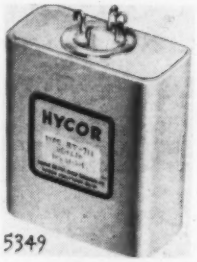
New "Model 160 TRIMpot" meets aircraft and missile requirements; utilizes new high-temperature mate-



rials and unusual manufacturing techniques to provide –65°F to 350°F operating temperature range; power rating 0.6 watt at 100°F and 0.4 watt at 200°F; resolution as fine as 0.25% over 25-turn adjustment range. Standard resistances from 10 to 10,000 ohms.—*Bourns Labs., 6135 Magnolia Ave., Riverside, Calif.*

For more information circle **312** on inquiry card.

Voltage Transformers



New miniature precision voltage ratio transformers feature accuracies to 0.01%; are available plastic-encapsulated or in hermetically-sealed cases. Units having up to 10 ratio taps are available.—*Hycor Co., 11423 Vanowen St., North Hollywood, Calif.*

For more information circle **313** on inquiry card.

Miniature Toroid Coils

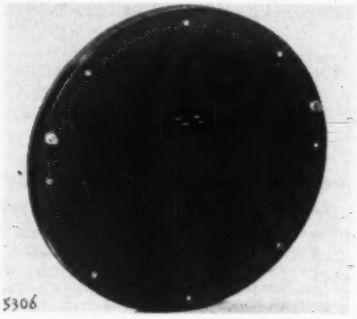
New toroid coils for use with transistors in both subminiature and graphic circuits are designed for quick insertion through transistor terminal boards. Windings are terminated in lugs, or solid wire leads. Leads can be tinned for dip soldering, or brought to any pin arrangement. Sizes from ⅝ in to

⅞ in OD. Inductance values up to 2 henries. Types for use with reactors provide as high as 150 Q in ⅝-in size illustrated, with rising Q values as coil sizes increase. Types for use in magnetic amplifiers, modulators and voltage regulators absorb up to 130 v, 400 cps, in units with 0.94-in. OD. Maker will wind coils to special sizes and inductance values.—*Forrest Mfg. Co., 5962 Smiley Drive, Culver City, Calif.*

For more information circle **314** on inquiry card.

4100-usec Delay Line

New solid fused quartz delay line produces delay of 4100 microseconds, equivalent to more than 300 miles of

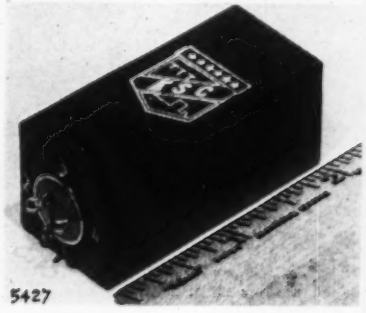


radar range. Carrier frequency is 8 Mc with a bandwidth of 2 Mc. Units of longer delay and higher frequency are possible.—*Andersen Labs., 39 Talcott Rd., West Hartford, Conn.*

For more information circle **315** on inquiry card.

3-usec Delay Line

New ultra-compact delay line provides a 3.0 usec delay with 0.4 usec



rise time at 2,000 ohms impedance and 10% attenuation; is epoxy-embedded and hermetically sealed; meets all MIL specs.—*E.S.C. Corp., 534 Bergen Blvd., Palisades Park, N. J.*

For more information circle **316** on inquiry card.

Pulse Transformers

New miniature pulse transformers for use in graphic circuitry are carried in stock in pulse widths ranging from 0.1 to 16.0 usec and in most popular 2-, 3- and 4-winding turns ratios; are said to feature unusually low rise times and leakage inductances; are suitable for insertion into graphic-circuit eyelet boards; come with standard 7- and 9-pin pattern headers. Can sizes range from 13/32 in height x 1/2 in OD to 5/8 in height x 3/4 in OD. All are epoxy-impregnated in hermetically-sealed cans, and will

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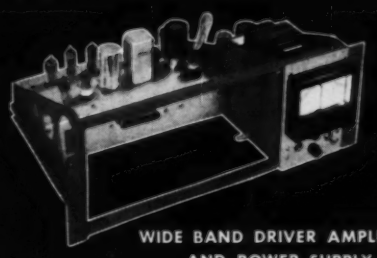
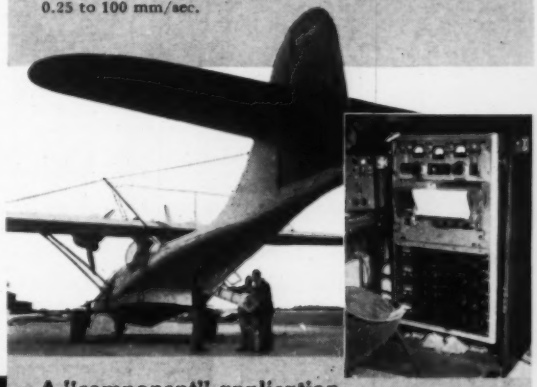
● SEPARATE COMPONENTS



WIDE BAND DRIVER AMPLIFIER AND POWER SUPPLY

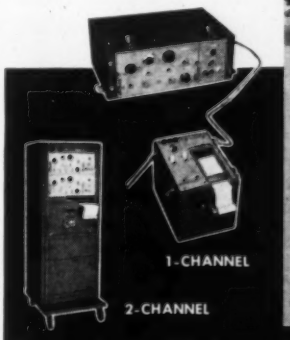
THIS amplifier (Model 150-300/700) is designed for use with low power galvanometer elements (output ±25 ma full scale into 100 ohm load), an oscilloscope and/or a panel meter, individually or simultaneously. Eleven plug-in type, interchangeable Preamplifiers are available for use with it, and include: AC-DC, Carrier, DC Coupling, Servo-Monitor, Log-Audio, Low Level, Input Network, AC Wattmeter, Frequency Deviation, Stabilized DC, and an RMS Volt/Ammeter.

Other available separate components include Recorder Assemblies from 1- to 8-channels, with chart speeds from 0.25 to 100 mm/sec.

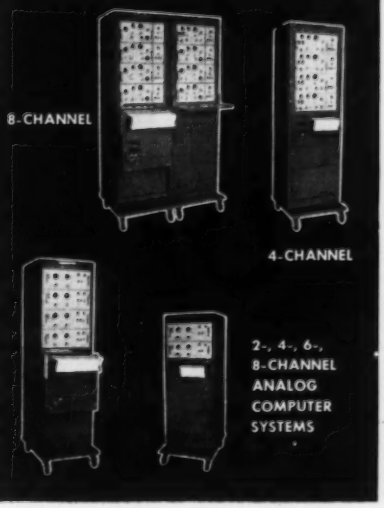


A "component" application

FOUR Model 67-300 DC Amplifiers and a Model 154-100 four-channel Recorder Assembly are integrated with other equipment aboard a "flying geophysical laboratory" by PSC Applied Research, Ltd. of Toronto to record data from dual frequency detector magnetic survey equipment and a radiation detector, plus elevation variations during flight. The simultaneous recording of all four provides valuable reference data when interpretations are being made.



● COMPLETE SYSTEMS



A Sanborn "150" system starts with a choice of an 8-, 6-, 4-, 2- or 1-channel basic assembly, to which the user adds any combination of plug-in type Preamplifiers to meet the numerous and changing recording requirements. Special 8-, 6-, 4-, and 2-channel systems are available for recording the output of analog computers, or other applications involving 1 volt cm sensitivity. Added to this application versatility and operating flexibility of Sanborn systems are other advantages, such as inkless recording in true rectangular coordinates . . . high torque (200,000 dyne cm) galvanometer . . . time and code marking . . . numerous chart speeds.

Let Sanborn engineers help you solve your recording problems. Write for complete specifications and performance data on any Sanborn component or system.

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NEW INSTRUMENTS

withstand shock, temperature cycling, vibration, and humidity requirements of MIL-T-27.—*PCA Electronics Inc., 2180 Colorado Ave., Santa Monica, Calif.*

For more information circle **317** on inquiry card.

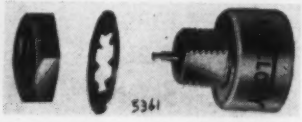
Hi-temp Capacitors

New "Type 118P Metal-Clad" subminiature metallized paper capacitors are said to provide "reliability in high temperature operation unmatched by any other type of metallized paper capacitor, are rated for operation at 125°C without voltage derating; and insulation resistance is higher than that of any other metallized paper capacitor.—*Sprague Electric Co., 409 Marshall St., North Adams, Mass.*

For more information circle **318** on inquiry card.

Tantalum Capacitor

New "XT Tantalum Capacitor" features integral mounting that withstands heavy shock and vibration;



threaded neck fits through a keyed slot in chassis; lock washer and hex nut are supplied. Capacitor operates at ambients from –55°C to 175°C, and can be supplied for use at 200°C. Wide selection of ratings.—*P. R. Mallory & Co., Inc., Indianapolis, Ind.*

For more information circle **319** on inquiry card.

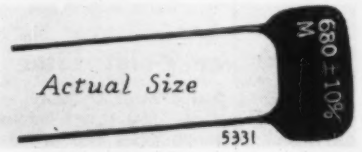
Shockproof Capacitors

New solid-dielectric "Glasseal" capacitors, capable of withstanding vibrational stresses of high acceleration and frequency as well as severe shock conditions, utilize new rugged compression-seal-type glass-to-metal solder-seal terminals. Operating range is –55°C to 125°C. Wide selection of ratings.—*Pyramid Electric Co., 1445 Hudson Blvd., North Bergen, N. J.*

For more information circle **320** on inquiry card.

Dipped-mica Capacitor

New "Dur-Mica DM-20" meets modern miniature requirements and all humidity, temperature and electrical



requirements of MIL-C-5; is available in capacitances up to 5100 mmf at 300vdcw and up to 3900 mmf at 500vdcw with operating temperatures up to 125°C.—*The Electro-Motive Mfg. Co., Inc., Willimantic, Conn.*

For more information circle **321** on inquiry card.

Germanium Power Rectifiers

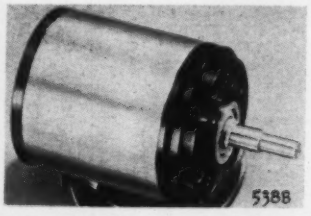
New diffused-junction germanium power rectifiers are said to open up many new fields heretofore requiring other methods for rectification; can be supplied for voltage ranges from 10 to 100,000 and from 10 to 100,000 amps. by connecting junctions and assemblies in series or parallel. One advantage over mercury-arc rectifiers is lower forward drop. Unlimited operating life can be expected over temperature range of –55°C to 75°C when equipment is designed to operate within ratings. Advantages over mercury-arc and mechanical rectifiers are reduction or elimination of moving parts and lower initial cost. Three styles: Natural-convection, forced-convection and liquid-cooled.—*International Rectifier Corp., El Segundo, Calif.*

For more information circle **322** on inquiry card.

ELECTROMECHANICAL COMPONENTS

Magnetic Clutch

New high-speed "Model T502," for control, computer and servo systems, can be mounted on a single hanger

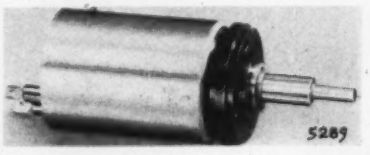


like any standard servomotor. Concentric input and output shafts are on mounting end.—*Sterling Precision Instrument Corporation, 34-17 Lawrence St., Flushing 54, N. Y.*

For more information circle **323** on inquiry card.

Miniature Magnetic Clutch

New "Model T 507-1" is said to feature excellent torque characteristics and high-speed engagement and disengagement times. It has the same case size as a MK 14 Mod O servomotor. Single-ended concentric input

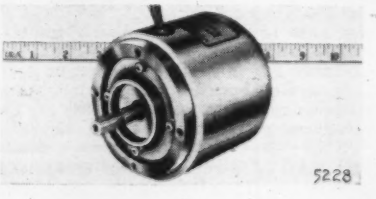


and output shafts are located at mounting end.—*Sterling Precision Instrument Corp., 34-17 Lawrence St., Flushing 54, N. Y.*

For more information circle **324** on inquiry card.

Capacitor-type Motors

New capacitor induction motors for automatic control, business machines, etc., are available in frequencies of 60 and 400 cps. sized at 3⅞-in diam for self-cooled continuous-duty and 3 5/16-in diam for fan or intermittent



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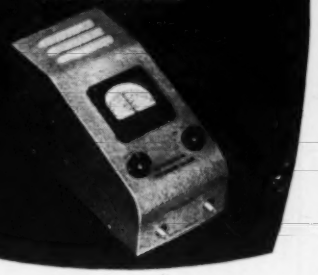
the most sensitive, self-contained differential pressure meter ever available



- Measures a wide range of static and dynamic pressure for gas and other non-conducting fluids.
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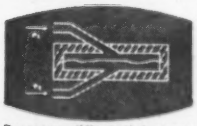
- Provides one micron of mercury resolution at atmospheric pressure . . . 7.5 volts output available for recording at a full scale differential pressure of 1 mm of mercury.



Pressure differential moves beryllium-copper diaphragm.

Ionization transducer converts motion into electrical signal.

Output applied to cathode follower to drive meter.

Two-knob control for balance . . . sensitivity.

Just plug this compact, completely self-contained meter into a 115V, 60 cy. line and you're *immediately ready for operation*. Based on the famous **"T-42" Ionization Transducer,** this astonishingly simple pressure instrument, only 5" x 5" x 10" in size, covers the widest range of application. In the laboratory or on the production line, it requires no special accessories, no specially trained personnel.

Details on this new micro-sensitive meter are in Instrument Data Sheet 303-1, available upon request to Technical Literature Section,

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For more information circle **102** on inquiry card.

Circle **103** on inquiry card. ⟶

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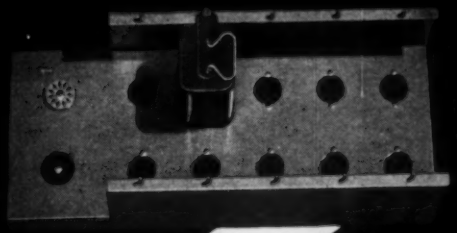
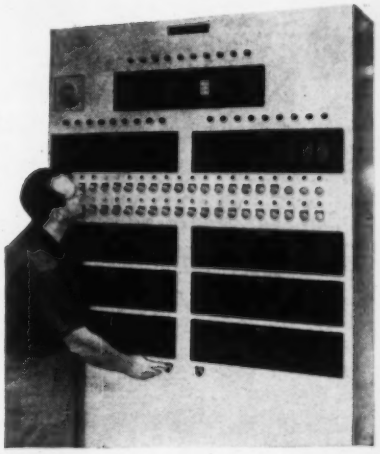
Examine for yourself every piece and component . . . consider the savings you realize through standardization and complete flexibility that only PANALARM "50" provides.

Then, evaluate *dependability*. Beyond all else, PANALARM "50" represents the greatest value in audio-visual alarm systems by its record of *dependable service* alone.

STANDARD CHASSIS

is interchangeable without re-wiring for all types of annunciator service: standard audio-visual; ringback; bullseyes or nameplates; trouble or running signals; lock-outs; or low drain operation.





PANALARM IS PROVEN!

In hundreds of plants—serving for many years—Panalarm Annunciators have demonstrated outstanding performance. They have won confidence for the very critical part they play in plant operation and safety.

PANALARM PLUG-IN UNITS

. . . *heart of the system* . . . incorporate finest telephone-type relays and special contact arrangements . . . assure sequential operation. Hermetically sealed suitable for Class I, Div. 2 locations.

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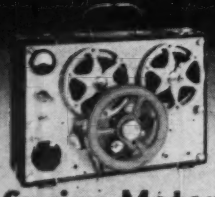
New VU Magnemite*



Spring-Motor Battery-Operated Portable Tape Recorder

Now you can consistently make professional recordings under the most gruelling field conditions. Tapes will faultlessly play back on all professional and home recorders. Ruggedly designed for maximum dependability and top-notch efficiency. Combines unlimited versatility of performance with extreme simplicity of operation. Choice of fourteen models available for every conceivable application.

Incorporates a multi-purpose VU monitoring meter for precise setting of recording level without earphone monitoring. Meter also accurately indicates condition of "A" and "B" batteries. Five single speeds as well as two, three and 4-speed models available. Units weigh only 19 lbs. with batteries and measure 6½" x 9½" x 14¼". Higher speed models meet NARTB standards. All recorders are guaranteed for One Full Year.

For complete technical specifications and direct factory prices write to Dept. IA.

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For more information circle **104** on inquiry card.

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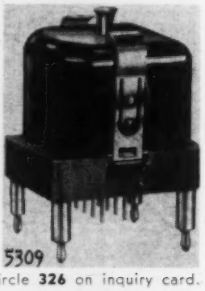
For more information circle **105** on inquiry card.

NEW INSTRUMENTS

duty. HP ranges from 1/10 to 1/100 at all standard voltages, single, double or three phase.—*Eastern Air Devices, Inc., 347 Central Ave., Dover, N. H.*
For more information circle **325** on inquiry card.

Polar Relay



New "Type 203, Series PWT," features new mounting, interchangeable with W.E.Co. 255; is recommended for use in composite signaling equipment, etc.—*Automatic Electric Sales Corp., 1033 W. Van Buren St., Chicago 7, Ill.*
For more information circle **326** on inquiry card.

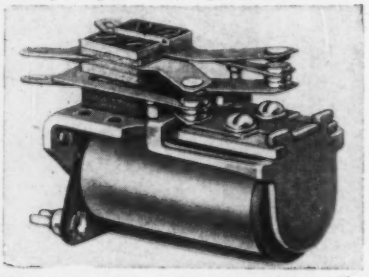
Latching Relays

New "L26F" units, said to be "by far the smallest and lightest" latching relays, are magnetically held and

electrically reset; are available in 2-, 4- and 6-p d-t contact arrangements. Continuous duty temperature range –65°C to 125°C; shock 50 *G*; meet MIL-R-5757B and MIL-R-25018.—*Filtors, Inc., Port Washington, N. Y.*
For more information circle **327** on inquiry card.

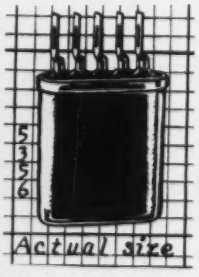
Miniature Power Relay

New miniature relay can switch currents up to 10 amps and is said to



offer "great operating sensitivity".—*Magnecraft Electric Co., 3350L W. Grand Ave., Chicago 51, Ill.*
For more information circle **328** on inquiry card.

Subminiature Relay



New "Model M-1000" is said to offer "for the first time" an extremely small relay which performs "as well as relays several times its size." Maker has circumvented miniaturization problem by introducing a permanent magnet into magnetic structure. This raises available torque, allows use of

RELAYS

ALLIED • LEACH • GUARDIAN
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For more information circle **106** on inquiry card.

SAVE FUEL DOLLARS

PORTABLE FLUE GAS ANALYZER

COMPLETE CO_2 READING TAKES ONLY 20 SECONDS
5 MODELS to choose from!

THE THERMCO ANALYZER IS A PROVEN INSTRUMENT FOR QUICKLY ADJUSTING ALL TYPES OF BOILERS AND HEATERS FOR MAXIMUM EFFICIENCY. CONSIDERABLE TIME SAVED OVER THE CHEMICAL METHOD, AND THE FINAL RESULTS ARE FAR MORE SATISFACTORY.

SEND TO-DAY: Complete facts on how to SAVE FUEL DOLLARS and maintenance man hours!

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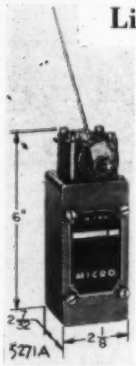
JOHNSON RD. · MICHIGAN CITY, INDIANA

For more information circle **107** on inquiry card.

full-size contacts and contact pressures with resultant performance equal to large-size relays, and makes available for the first time a polarized relay in a subminiature configuration.—*Luther Mfg. Co., 7312 Varna Ave., North Hollywood, Calif.*

For more information circle **329** on inquiry card.

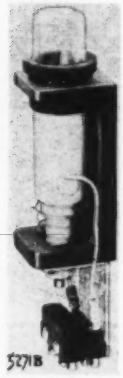
Limit Switch



New low-force heavy-duty limit switch has for its actuating lever a 5-in aluminum rod which can be bent (or cut shorter) to fit user's need. Minimal operating force at 5-in length is 2½ oz; differential travel is 5° and overtravel allowance is 60°. Rating 10 amps at 120, 240 and 480 volts. —*Micro Switch Div., M-H, Freeport, Ill.*

For more information circle **330** on inquiry card.

Illuminated-button Switch

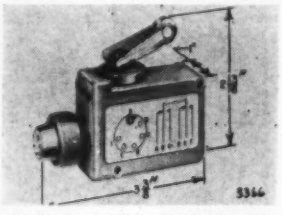


New "31 PB1" features an indicating light as part of button; is easy to wire; can be panel-mounted in groups on 1-in centers; has socket inside head of pushbutton for a single-contact miniature bayonet lamp (lamps not supplied with switches). Removable translucent pushbuttons are available in red or frosted white for use with No. 51 neon bulbs; must be ordered separately. — *Micro Switch, Freeport, Ill.*

For more information circle **331** on inquiry card.

Environment-proof Switches

New "Series EP" (environment-proof) limit switches are sealed and contain an inert gas; offer a variety



of electrical rating and circuitry selections; are available in either side-or bottom-mounting designs; meet vibration and shock-resistance tests (MIL-S-6744) and immersion tests (MIL-E-5727A).—*Micro Switch, Freeport, Ill.*

For more information circle **332** on inquiry card.

Miniature Test Jacks

Three new styles of eight color-coded test jacks make possible quick and accurate circuit testing in standard, miniature, and subminiature equipment; provide convenient test

Unsurpassed
IN PERFORMANCE

Unequalled
IN COMPACTNESS

CHARACTERISTICS
2 degrees of freedom
... 360° in roll, ±82° in pitch
Repeatability to established vertical
... 15 Minutes max. of ½ cone angle
Free drift rate
... 0.5° Minute
Erection Time
... 3 minutes at start
Erection Rate
... 3° minute-Normal 80° minute-Fast
Synchro Output (each axis)
... 11.8 volts, 400 cycles

Only Kearfott can offer a *Miniature* Vertical gyro with big gyro *Performance*. Completely self contained, this gyro requires *No External Erection Amplifiers*. A gravity sensitive electrolytic device, within the gyro, directly associated with the torquer motors, provides the necessary vertical reference.

Hermetically Sealed, filled with a dry, inert gas. Satisfies the requirements of MIL-E-5272 as regards shock test (Procedure II) humidity, salt spray, fungus resistance, rain, sand, dust, immersion and explosion proof.

This gyro duplicates the performance of the Kearfott T2108 series in *⅛ the volume and weight.*

KEARFOTT COMPONENTS INCLUDE:
Gyros, Servo Motors, Synchros, Servo and Magnetic Amplifiers, Tachometer Generators, Hermetic Rotary Seals, Aircraft Navigational Systems, and other high accuracy mechanical, electrical and electronic components.

Engineers: Many opportunities in the above fields are open. Please write for details today.

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For more information circle **108** on inquiry card.

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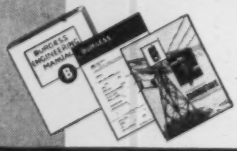
For more than forty years, Burgess has offered to Electronic Engineers design and engineering facilities to meet any dry battery need. Burgess welcomes the opportunity to assist in solving your problems. Burgess popularity is based on uniform performance and consistent high quality that have earned and held the respect of Engineers everywhere. Your local distributor carries a complete stock of Burgess Industrial Batteries.



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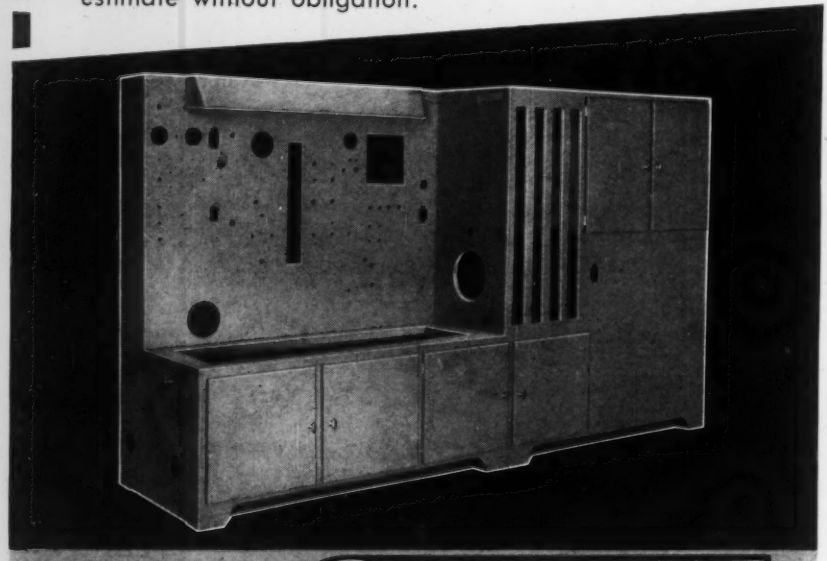
FREEPORT, ILLINOIS

For more information circle **109** on inquiry card.

Is size, accuracy, delivery or price *your* problem? Then be sure to have Littleford fabricate your cabinet, cubicle or control panel. Mail us your blueprint for prompt estimate without obligation.



Fabricators of plate and sheet metal products for industry since 1882

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LITTLEFORD BROS., INC.
404 E. Pearl St., Cincinnati 2, Ohio

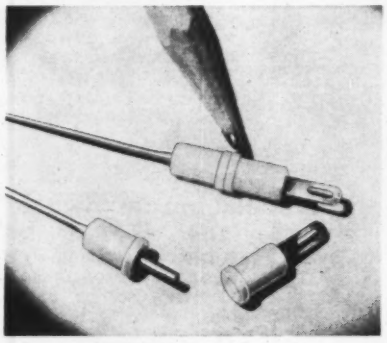
For more information circle **110** on inquiry card.

points for standard 0.080-in test prod. One style, expressly developed for use with printed circuits, can be securely assembled in any desired location on printed-circuit panels up to ¼-in thick in one easy soldering application.—*Raytheon Mfg. Co., Waltham 54, Mass.*

For more information circle **333** on inquiry card.

Teflon-insulated Connectors

New miniature two-piece connector featuring superlative insulating properties of Teflon, for breakaway connections, comprises a feed-through



plug with pigtail terminal, and a contact receptacle.—*Sealectro Corp., 186 Union Ave., New Rochelle, N. Y.*

For more information circle **334** on inquiry card.

MECHANICAL COMPONENTS

Ball-&-disc Integrator

New five-inch "Model 246" features two integrator sections driven by a common input; input speed 0 to 150

rpm; unidirectional output speed 0 to 0.8x input rpm; reversible 0 to 0.4x input rpm; output torque to 16 oz-in; error less than 0.5%.—*The Reflectone Corp., Stamford, Conn.*

For more information circle **335** on inquiry card.

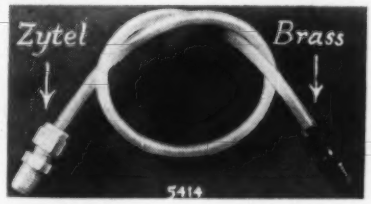
Control Rods for Ball-&-disc Integrator

New (in availability and standardization) control rods, 3/16-in diam, can be supplied with vernier end, screw threaded end, rack end, or plain. Special lengths and configurations can, as before, be made to customer specifications.—*Engineering Sales Dept., The Reflectone Corp., Stamford, Conn.*

For more information circle **336** on inquiry card.

Tube Fittings

New "Swagelok" tube fittings, made of "Zytel" polyamide resin for plastic tubing where corrosion is a problem, are said to be the first to be made in

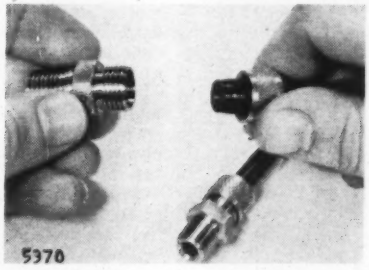


elbows, tees, reducers, adapters, plugs, caps and bulkheads. No preparation of tubing needed: merely insert tubing in fitting and tighten nut.—*Crawford Fitting Co., 884 E. 140th St., Cleveland 10, Ohio.*

For more information circle **337** on inquiry card.

Plastic-tube Fitting

New "Intru-lok" flareless-type brass fitting for instrumentation lines features knurled nut used with an insert-

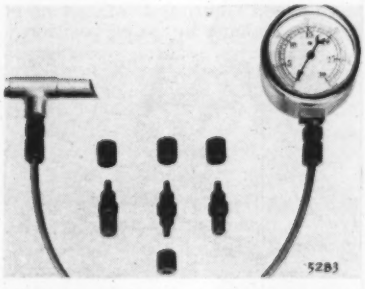


expander. When nut is turned up finger-tight, tube wall is squeezed firmly for a leakproof joint.—*The Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.*

For more information circle **338** on inquiry card.

PVC Adaptors and Unions

New smaller sizes of polyvinyl chloride fittings and adaptors for connecting polyethylene and other flexible



tubing are suitable for tubing-to-tubing and tubing-to-pipe connections in ¼-in and ⅜-in size range; can be used for many types of flexible instrumentation tubing connections; resist a wide group of chemicals; are non-inflammable and rot-proof; will withstand working pressures of 125 psi.—*S. & C. Mfg. Co., 6245 Wiehe Road, Cincinnati 13, Ohio.*

For more information circle **339** on inquiry card.

Glass-to-metal Seals

New "Mechanical Assemblies" are specially-designed "Vac-Tite Seals" said to furnish maximum economy and

From MOOG Servo Valves . . .

Compactness

For control systems with space and weight limitations, Moog Servo Valves are exceptionally well suited because of their compactness. For instance, maximum dimensions of the new Model 2000 Dry Solenoid Servo Valve are 3.06 x 1.94 x 1.90 inches. Weight is 0.7 lbs.

Compactness is only one of the outstanding characteristics of these proportional type, four-way valves. They also are known for their sensitivity, linearity, reliability, and high dynamic performance. Equivalent time constants are as low as one and one half milliseconds from input differential current to output flow.

Performance of this magnitude makes possible control systems of high accuracy and response. Typical applications for these valves are in servo systems of advanced aircraft and guided missile flight controls, radar scanner actuation, contour following machine tools, and automatic packaging equipment.

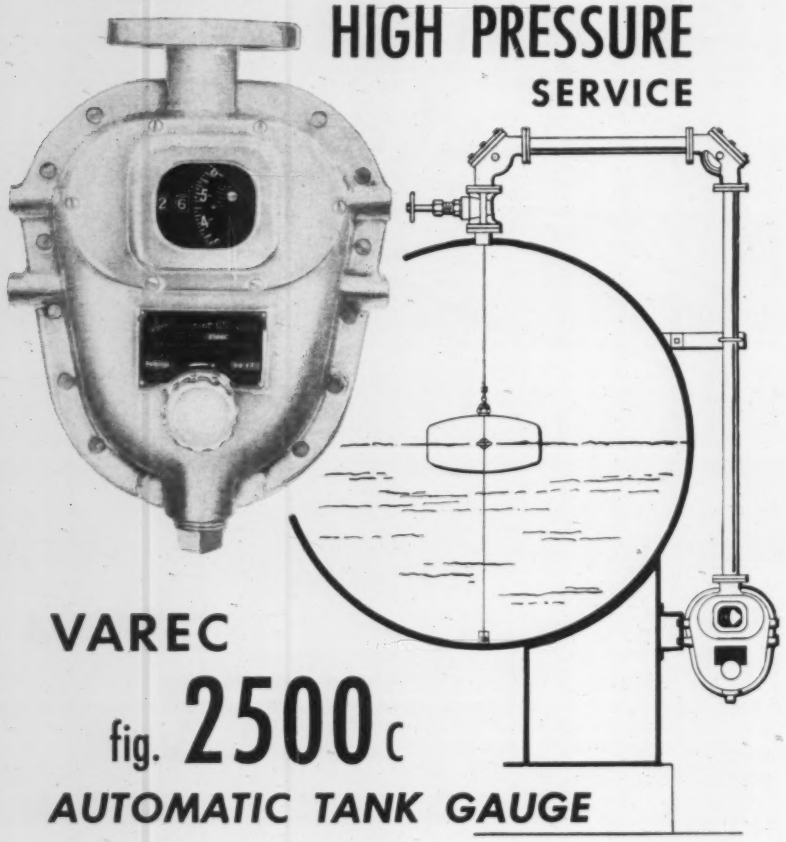
Production models are designed to operate in hydraulic systems of from 1000 to 3000 PSI pressure. Rated output flow from 0.1 to 50.0 GPM, for control currents between 2.0 and 40.0 milliamperes as specified, are available in production units.

For details write for Bulletin 2000-3

MOOG VALVE CO., INC. PRONER AIRPORT EAST AURORA, N. Y.

For more information circle **111** on inquiry card.

NOW- Available for HIGH PRESSURE SERVICE



VAREC fig. 2500C AUTOMATIC TANK GAUGE

Service in working pressures to 300 p.s.i.g. is offered by the new VAREC Figure 2500C Automatic Tank Gauge. It's a high pressure model of the successful VAREC Figure 2500 Series, equipped with the Neg'ator motor, which eliminates use of counterweight and simplifies installation. This series has been tested by 3 years of service in the Petroleum and Chemical fields, after 2 years of experimental and development work.

An important part of this new model is the magnetic drive, which requires no packing gland or mechanical seal on rotating shaft. The use of stainless steel ball bearing construction throughout provides a combination that reduces friction to a minimum.

Liquid level indication on a mechanical counter and dial for convenient, easy reading. Components are enclosed in a separate compartment to keep tank vapors from fogging dial. Operation checker is standard equipment.

Like the low pressure series Figure 2500 gauges, addition of remote gauger transmitter or control devices is a simple field installation. It is not necessary to remove the gauge head or disturb the original installation in any way.

Varec

VAPOR RECOVERY SYSTEMS COMPANY
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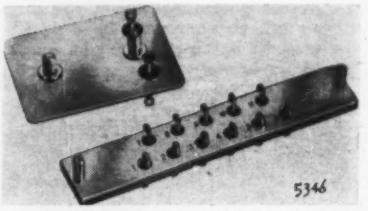
Compton 1, California

961-9

Cable address: VAREC COMPTON Calif. (U.S.A.) All Codes

For more information circle **112** on inquiry card.

NEW INSTRUMENTS

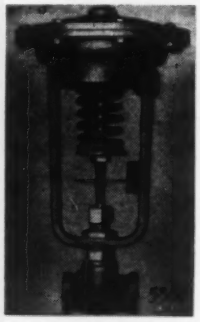


mounting security. Line now includes color-coded terminal plates, lock-ring safety seals, attached bracket seals, unit headers and terminal strips.—*Hermetic Seal Products Co., 33 S. Sixth St., Newark 7, N. J.*

For more information circle **340** on inquiry card.

VALVES

D-m Control Valves

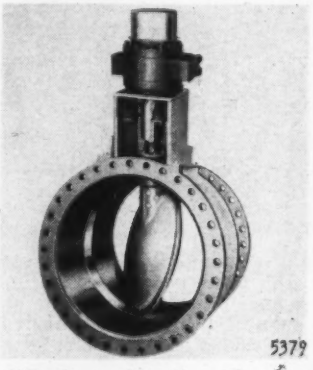


New "Series 400" diaphragm-motor valves are said to "incorporate a number of engineering design improvements to provide improved flow characteristics for medium-duty valves." Line includes double-seated, single-seated and three-way types for use in either on-off or proportional control systems. On-off single-seated model can be supplied with a plug having a soft composition disc for bubble-tight shutoff.—*Valve Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.*

For more information circle **341** on inquiry card.

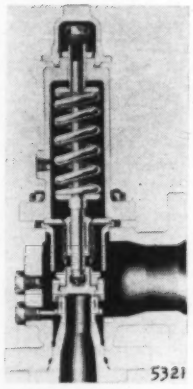
Butterfly Valve

New 36-in stress-sealed butterfly valve meets rigorous tolerance of permissible leakage in closed position under difficult combination of pressures to 200 psi and temperatures to 1300° F. When disc is rotated to closed position, it seats against an Inconel-X band in valve body. This band is then inflated under nitrogen pressure. Offset shaft design permits full 360° sealing surface of disc without need of shaft going through stress seal band. —*W. S. Rockwell Co., 200 Eliot St., Fairfield, Conn.*



For more information circle **342** on inquiry card.

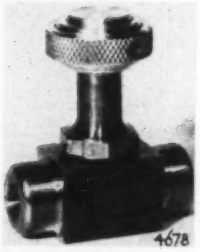
Relief Valve



New "Model JB Protecto-Seal Bellows" relief valve has several exclusive features, among them "Bellows Protector" that shields bellows from adverse turbulent effects, preventing fatigue-caused premature failure; acts also as a positive lift-stop preventing over-compression. Available for pressures from 25 to 2500 psi, in eleven orifice sizes, in 1-in to 6-in inlet sizes; also with internal heating coils and flushing coils where required. —*Crosby Steam Gage & Valve Co., 43 Kendrick St., Wrentham, Mass.*

For more information circle **343** on inquiry card.

Metering Valve

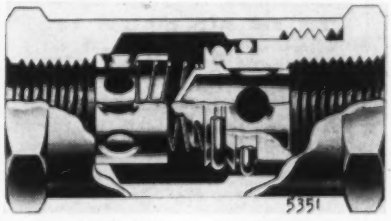


New ⅛-in leak-proof metering valve is said to make possible "fingertip hair-line control of a water manometer when connected directly to pressures of 2500 psi." Over-torquing cannot damage needle or seat as buffer plate and metering pin act as a forming die. It is impossible to score needle or Teflon seat. Service temperature range −110°F to 500°F. Valve can be completely overhauled in minutes without disturbing plumbing or mounting.—*Robbins and Associates, 1735 West Florence Ave., Los Angeles 47, Calif.*

For more information circle **344** on inquiry card.

Check Valve

New "200-I Series Circle Seal" check valve, for 3000 psi, is said to feature "heavier, more rugged con-



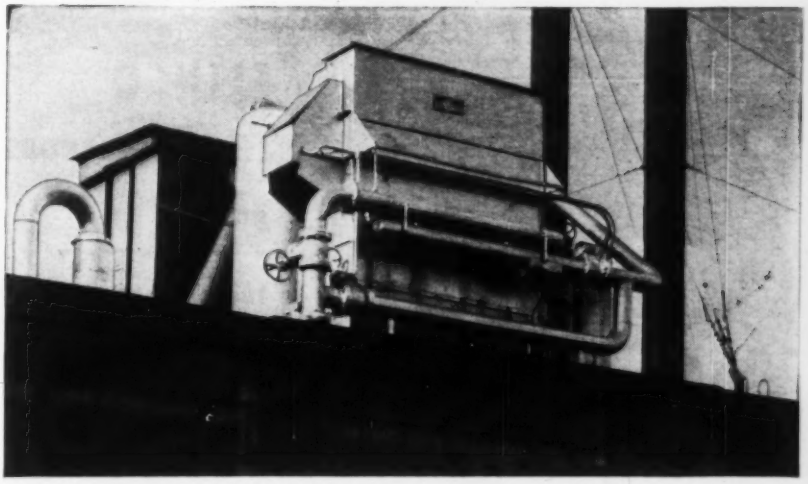
struction which will absorb more abuse in handling and installation." Location of static O-ring body seal confines pressure to strongest part of body. Cracking pressure 0.5-1.0 psi. Bodies of brass, aluminum, steel and stainless steel; sizes from ⅛-in to 2-in.—*James-Pond-Clark, 2181 E. Foothill Blvd., Pasadena 8, Calif.*

For more information circle **345** on inquiry card.

Check Valve

New "Technocheck" is said to perform with "unusual efficiency and economy" and to have a longer life

Direct saving of cooling water expense returns to you the cost of a Niagara Aero After Cooler in less than two years.



How to Get Drier Compressed Air:

It prevents many troubles and saves much expense

● NIAGARA AERO AFTER COOLER cools compressed air or gas below the temperature of the surrounding atmosphere. Therefore you get no further condensation in your lines. You save much in repairs to pneumatic tools and equipment; you save much interruption to production; you save water damage in paint spraying, in air cleaning, in any process where compressed air comes in contact with your materials or parts in manufacturing (sand blasting, for example).

Niagara Aero After Cooler uses evaporative cooling, saving 95% of your cooling water consumption. This saving quickly returns the cost of the equipment to the owner or makes extra cooling water available for other processes.

The Niagara Aero After Cooler produces compressed air with 30% to 50% less moisture than by ordinary cooling methods. Other Niagara equipment provides bone-dry air for processes requiring it.

If you have an air problem or a cooling problem, a Niagara engineer probably has an answer that will improve your process or save you operating or maintenance expense.

Write for Bulletin 98

NIAGARA BLOWER COMPANY

Over 35 Years Service in Industrial Air Engineering

Dept. IN., 405 Lexington Ave. New York 17, N. Y.

Experienced District Engineers in all Principal Cities

For more information circle **113** on inquiry card.

every indication points to

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SELF-SYNCHRONOUS UNITS

for remote indication and control of

FLUID LEVEL

DIFFERENTIAL MEASUREMENT

PRESSURE

POSITION

MOTION

ANGULAR DISPLACEMENT

Cost-saving Elinco Commercial Type Units are right by every indication — just what you need for day-in-day-out use, or for special indicator-control applications — yet you save up to half the usual cost with Elinco —

★*Motors and Generators* for direct "back-to-back" indicator installations

★*Resolvers* for use in torque amplification and servo control systems where extreme accuracy is not required

★*Phase Shifters* where "sensing" must be expressed as a phase relationship

★*Rotatable Transformers* where rotor displacement varies voltage output, for process control and similar applications

FEATURES AND SPECIFICATIONS — Every Elinco unit is a precision instrument manufactured to highest standards, 100% electrically tested, individually balanced dynamically and statically, and carefully produced under step-by-step quality control of all components.

Type	Dimensions	Accuracy	Torque at Max. Phase Displacement	Torque Gradient within ±10° Displacement
Midget	2½" dia. x 3"	3°	2.5 oz. in.	.03 oz. in./deg.
FB	2½" dia. x 4"	2°	4.2 oz. in.	.053 oz. in./deg.
A	3⅜" dia. x 6⅜"	1°	18.0 oz. in.	.28 oz. in./deg.

All above types have 115-volt, 60-cycle primaries, 34-volt secondaries. Special units can be supplied with accuracies, torques, and electrical characteristics to order.

When you specify Elinco Self-synchronous Units, you not only save substantially, but you receive units made by specialists with years of experience producing instrument-type rotary electrical equipment, outstanding for efficient design, precision, and quality. Send us your specifications . . . let us go to work for you now.

COMMUTATOR MOTORS ★ AC MOTORS ★ AC and DC GENERATORS ★ SPECIAL ROTARY UNITS

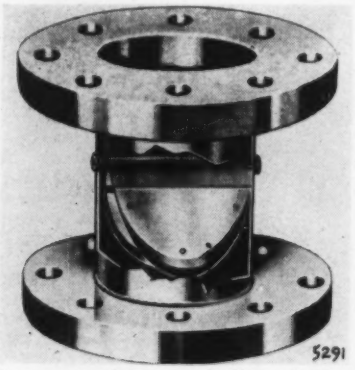
Custom manufactured in a variety of types to meet individual specifications for precision instrument and control applications. Write for catalogs.

ELECTRIC INDICATOR COMPANY, INC.
106 Camp Avenue • Springdale, Connecticut

ELINCO

For more information circle **114** on inquiry card.

NEW INSTRUMENTS

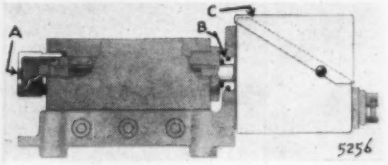


"than any known similar device." Unique design does not use a valve seat: employs valve body for that purpose; permits unrestricted straight-line flow; is silent. When flow reverses, valve elements instantly expand against valve wall, effecting a perfect seal with smooth "hammerless" action. Valve can be built of any of a wide range of materials. Standard (to 50 psi and 200°F) or custom designs, with either automatic or manual locks.—*Techno Corp., 16-30 West 5th St., Erie, Penna.*

For more information circle **346** on inquiry card.

Solenoid Valves

New "Quick-As-Wink O-type Solenoid Valves" for pneumatic and hydraulic control have three changes to

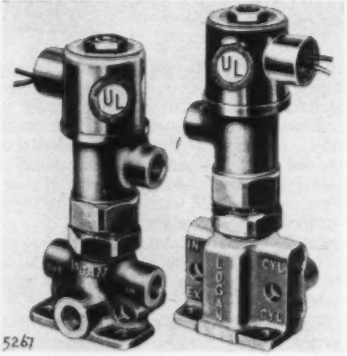


protect all operating parts from dust and grit: (A) sintered bronze filter in breather hole of spring cap; (B) sleeve sealed with "O" rings at two places; (C) top half of new two-piece cover for solenoid overlaps and fits tightly over bottom half.—*C. B. Hunt & Son, Inc., Salem, Ohio.*

For more information circle **347** on inquiry card.

Air Control Valves

Three new air control valves: "Model 6668" solenoid bleeder, air cylinder-actuated, 2- or 3-way valve. Removing plug in lower (center) port makes 2-way valve into a 3-way valve. ★"Model 6669" dual-control 2-way valve, same but has two exhaust open-

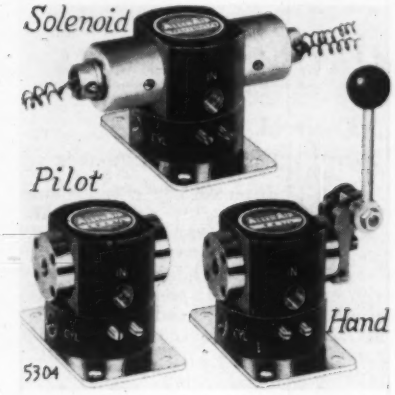


ings which permit bleeding both ends of master valve alternately, whence automatic reversal when current to solenoid is shut off. ★"Model 6678" 4-way, 2-position valve for operating double-acting air cylinders; requires maintained contact of control switch to direct air flow "out" lower cylinder port. Release of switch interrupts current to solenoid and directs air flow "out" upper cylinder port and exhausts cylinder at lower port for reversal.—*Logansport Machine Co., Logansport, Ind.*

For more information circle **348** on inquiry card.

Air Valves

New line of Air Control Valves comprises 24 models previously used as integral parts of "AllenAir" cylin-

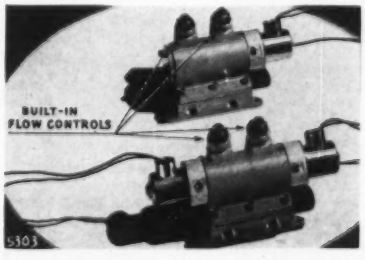


ders; now also presented commercially. Double solenoid units, for 8 volts or 110 volts, as well as air bleed models, are of momentary contact type. Hand and air pilot units are offered either for double actuation or spring return.—*A. K. Allen Co., 57 Meserole Ave., Brooklyn 22, N. Y.*

For more information circle **349** on inquiry card.

Solenoid Control Valves

New "Master-valve Series" comprises simple base-mounted air-control units designed to meet JIC standards.



Both double- and single-solenoid pilot-operated control valves have built-in flow controls which make them dual-purpose valves. Solenoids are rated continuous duty 10 watts maximum. Valve sizes: ¼, ⅜, ½ and ¾ in; air pressures from 20 to 150 psi for double solenoid and 35 to 150 psi for single solenoid.—*Airmatic Valve, Inc., 7317 Associate Ave., Cleveland 9, Ohio.*

For more information circle **350** on inquiry card.

Flow Regulator

New "Model #1407-4" is a full-range regulator for flow requirements between 0.5 and 20 gpm. Minimum to

transistor and
digital computer techniques

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For more information circle **115** on inquiry card.

Tube Race—the latest addition to the Instrof System of INSTRUMENT TUBING SUPPORT

INSTROF®

Instrof, the completely prefabricated method of supporting Instrument Tubing announces Tube Race, a simple channel section, specifically designed to provide an inexpensive yet permanent means for supporting and protecting a limited number of tubes in branch runs to and from the "Main Line" Instrof System.

Basically, Instrof Tube Race is a channel equipped with tube clips permanently installed during manufacture. It is designed to accommodate from two up to six ¼" tubes or three or four ⅜" tubes.

The addition of Tube Race makes the present Instrof System capable of handling almost any tubing support problem which could conceivably arise. Instrof is relatively inexpensive too, and with low installation time and almost no maintenance it becomes an extremely economical system.

For further information on how Instrof can help you save money and increase efficiency, write for the new Instrof Catalog. Ask for Bulletin I-9.

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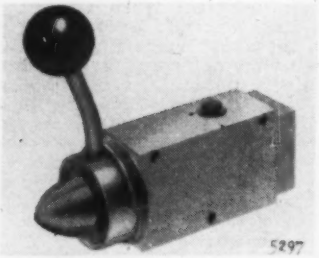
For more information circle **116** on inquiry card.

NEW INSTRUMENTS



maximum flow regulator adjustment is obtained by 180° handle rotation; flow-rate changes easily made under pressure.—*Waterman Engineering Co., 725 Custer Ave., Evanston, Illinois.*

For more information circle **351** on inquiry card.

MISCELLANEOUS

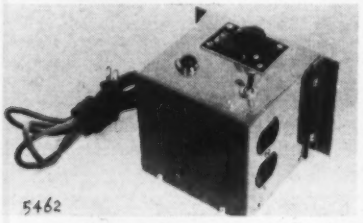
Control Center for Pathological Incinerators

New model of maker's "Control Center" makes it possible to eliminate smoke and odor nuisances caused by improper combustion in pathological incinerators used by hospitals and research centers for disposition of contaminated animals used in experiments.—*Wheelco Instruments Div., Barber-Colman Co., 1300 Rock St., Rockford, Illinois.*

For more information circle **352** on inquiry card.

Overload Relay

New "Electronic Over-load Relay" provides precise motor torque control for assembly lines: instantly cuts off

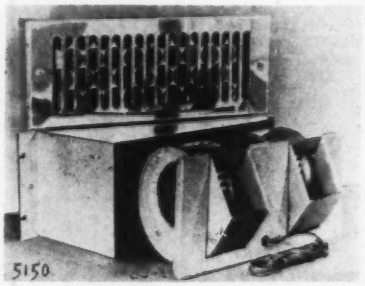


a motor if any load above workload is required; protects motor against burnout; is an additional safety factor for protection of operators.—*Morrow Products, Inc., 3339 Forbes St., Pittsburgh 13, Pa.*

For more information circle **353** on inquiry card.

Cabinet Cooling Blower

New "Model 2E408", specially designed to fit standard 19-in electronic rack, pressurizes cabinet with 300 cfm of filtered air, preventing dust from entering through cracks and joints.

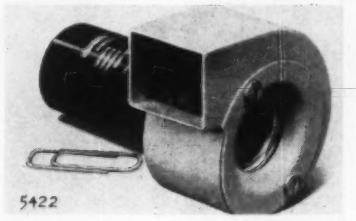


Filter is replaced from front by removing stainless steel grille. Assembly is complete in one unit, ready for use. Standard RETMA notching allows mounting on rack without cutting and fitting. Only grille is seen when mounted in cabinet.—*McLean Engineering, Box 228, Princeton, N. J.*

For more information circle **354** on inquiry card.

Miniature Blower

New high-velocity subminiature centrifugal blower for cooling airborne electronic equipment, etc., weighs less than 6 oz.; meets MIL



specs; is available in either rotation and in single- or double-ended models. Single-ended 20,000-rpm blower delivers 13 cfm at zero static pressure (11,000-rpm, 7 cfm). Motor is available in single- or 3-phase 400 cps or variable frequency.—*Eastern Air Devices, Inc., 355 Central Ave., Dover, N. H.*

For more information circle **355** on inquiry card.

Soil Moisture Meter

New "Bouyoucos Soil Moisture Meter" reads directly in percentage of available soil moisture; provides a

positive means of controlling irrigation. It is used in conjunction with plastic-impregnated gypsum blocks buried in soil at root level.—*Industrial Instruments, Inc., Cedar Grove, N. J.*

For more information circle **356** on inquiry card.

Voltage Regulator

New "Model 110 Magnetic Amplifier Type Voltage Regulator," is for use with a 400-cps alternator, is designed for m-g sets up to 30 kw, driven by induction or synchronous motors; has no moving parts; measures 3½ x 10 x 10 in; has passed USAMC's full testing procedures including tests for operation over ambient temperature range of 60°C (–76°F) to 71°C (159.8°F), also sand,

HEILAND OSCILLOGRAPH CHARTS "NIGHTGLOW" ON LONELY MOUNTAIN PEAK

Dr. Franklin E. Roach, consulting physicist to the National Bureau of Standards, loads a record take-up drum into the Heiland oscillograph.

On wind-swept "Fritz Peak" in the Colorado Rockies, the broad capacity of the Heiland 712 oscillograph goes to work on every cloudless and moonless night, charting the airglow in the sky.

Charting these night-light phenomena formerly required 30 minutes, but a complete record of the skies is now taken every 3 minutes.

A 4-telescope Photometer—installed at the top of the 9,000 foot mountain—sends information on the amount and quality of light in the skies to the Heiland 712 Oscillograph located in the trailer laboratory below. Heiland galvanometers convert these data into clear, easily-readable oscillograms for later study.

The National Bureau of Standards "Airglow" Project is engaged in a study of the earth's upper atmosphere. It is expected that this research will reveal high-speed fluctuations in the airglow, which originates in that part of the upper atmosphere known as the ionosphere.

Heiland Series 700-C Recording Oscillographs provide record widths as great as 12 inches, accommodate up to 60 channels and have record speeds through 144 inches per second. Galvanometers with unequalled sensitivity ratings are available in frequencies up to 5000 cps.

• Write for Bulletin 700CFPA for details.

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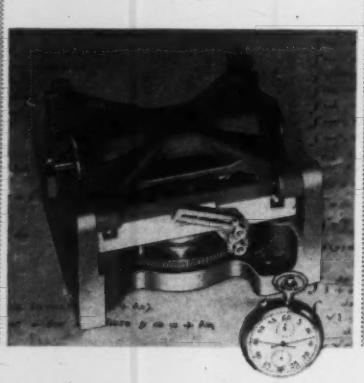
A DIVISION OF MINNEAPOLIS-HONEYWELL
130 E. 5th Ave., Denver 3, Colo.

For more information circle **117** on inquiry card.

MECHANICAL INTEGRATORS

from FORD INSTRUMENT

for extreme accuracy in computing and variable speed applications



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FORD INSTRUMENT COMPANY
Division of Sperry Rand Corporation
31-10 Thomson Ave.
Long Island City 1, N. Y.

Ford Instrument's standard components

For more information circle **118** on inquiry card.

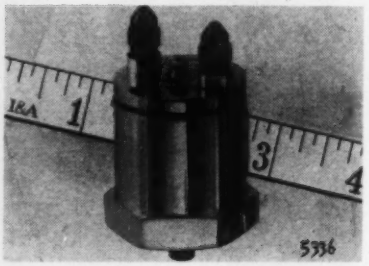
NEW INSTRUMENTS

fungus, humidity and dust.—*Magnetic Instrument Co., 82 Main St., West Orange, N. J.*

For more information circle **357** on inquiry card.

Acceleration Pickup for High-temperature Spots

New "Model 2205" has a dynamic acceleration range from 0 to 1000 *G* while operating at temperatures up to



2200°F; weighs 5 oz; features a high (at least 10 mv/*G*) and flat frequency response from 2 cps to 4000 cps.—*Endevco Corp., 180 East California St., Pasadena 1, Calif.*

For more information circle **358** on inquiry card.

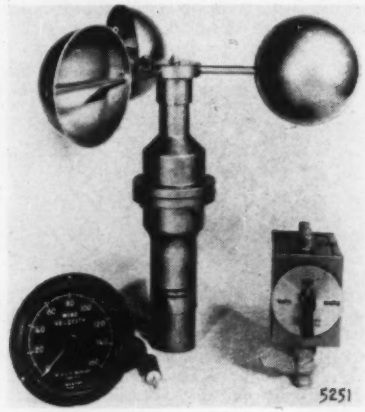
Line-voltage Regulator

New Automatic Line Voltage Regulator, for precision machinery, is for a 220-volt source and maintains output voltage within 0.5%. Output voltage can be set at any value between 210 and 240. Regulator handles up to 8½ kva loads. Correction rate is about 20 volts per second.—*Elox Corporation of Michigan, 740 N. Rochester Rd., Clawson, Mich.*

For more information circle **359** on inquiry card.

Anemometer

New model of maker's Wind Velocity Transmitter reads wind velocity in three units: mph, kmph, or knots,



interchangeably by a selector switch. Indicator pointer instantly adjusts to correct reading. Anemometer is wind-powered; is accurate within 2% at velocities from about 2 to 100 mph.—*W. & L. E. Gurley, Troy, N. Y.*

For more information circle **360** on inquiry card.

Stroboscopic Light Source

New "Type 1200 D Stroboflash" features neon tube giving flash duration of 10 to 15 microseconds. Direct-reading speed-measuring range 250-18,000 rpm in three overlapping ranges with 1% accuracy; practical upper limit about 100,000 rpm.—*Hickok Electrical Instrument Co., 10528 Dupont Ave., Cleveland 8, Ohio.*

For more information circle **361** on inquiry card.

If the inquiry card in this issue has been used by someone else, use the form below. Insert Inquiry No., sign, and mail to:

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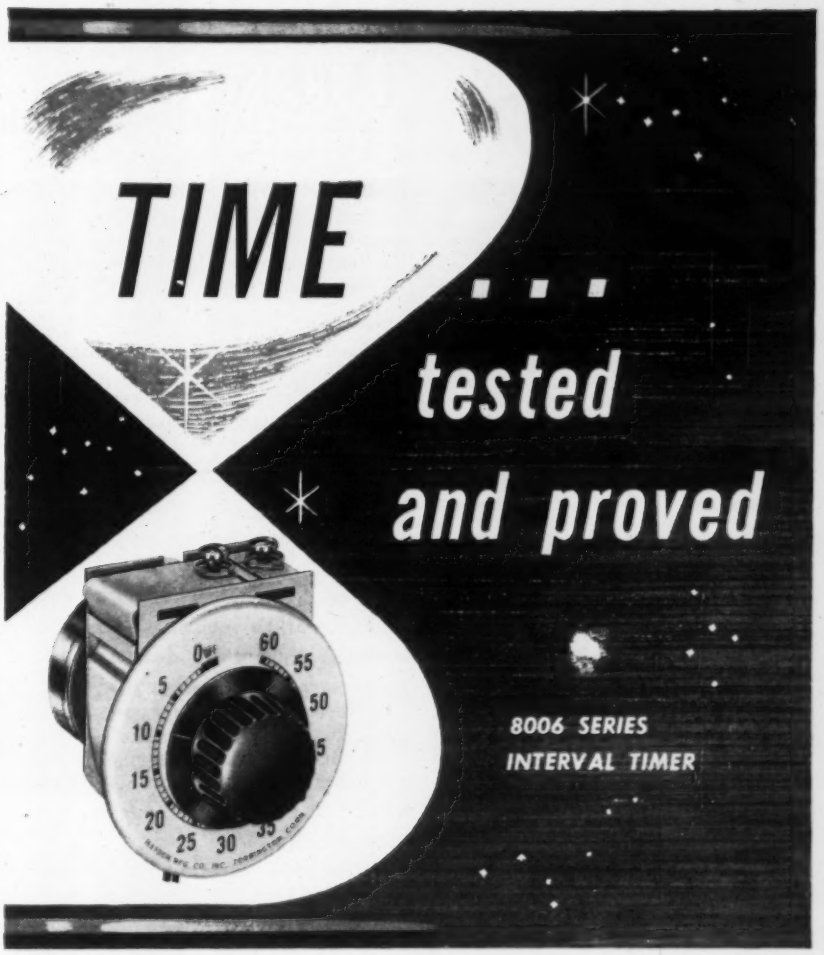

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For more information circle **119** on inquiry card.

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NOV. 14-17
1955

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Events . . .

For Other Computer Events see page 1506.

September 20-23

Fourth Beinnial of High Precision at the Chambre Syndicale Nationale de la Mécanique de Haute Précision, 37 Avenue de Breteuil, Paris, France.

September 28-29

Industrial Electronics Conference, Rackham Memorial Auditorium in Detroit, Michigan. For information contact Guido Ferrara, 8106 West Nine Mile Rd., Oak Park 37, Mich.

September 28-30

Sixth TAPPI Testing Conference including Instrument Exhibition at Sheraton-Kimball Hotel, Springfield, Mass. For information contact Wm. Schoenberg, 1878 E. 18th St., Cleveland 14, Ohio.

October 3-5

11th Annual National Electronics Conference, Hotel Sherman, Chicago, Ill. For information write J. Kocek, c/o Illinois Bell Telephone Co., 208 W. Washington St., Rm 300, Chicago 6, Ill.

October 3-6

25th Annual Meeting of Society of Exploration Geophysicists, Shirley Savoy Hotel, Denver, Colo. For information write Colin Cambell, 624 S. Cheyenne, Tulsa, Oklahoma.

October 5-14

Tenth General Conference on Weights and Measures will be held in Paris and Sevres, France. For information write National Bureau of Standards, U. S. Dept. of Commerce, Washington 25, D. C.

October 13-14

Denver Research Institute Second Annual Symposium on Analog and Digital Computers, Student Union Memorial, University of Denver, Denver, Colorado. For information write William Andrews, DRI, University of Denver, Denver 10, Colorado.

October 13-15

Committee on Vacuum Techniques, Inc., will hold their Second Symposium on Vacuum Technology at Mellon Institute, Pittsburgh 13, Penna. For information write Rudy Koehler, c/o Box 1282, Boston 9, Mass.

October 20-22

The Institute of Management Sciences Annual National Meeting will be held at the Park Sheraton Hotel, New York City, N. Y.

October 24-25

First Annual Technical Meeting of the Professional Group on Electron Devices of the I.R.E., will be held at The Shoreham Hotel, Washington, D. C.

October 27-28

Eleventh Annual Meeting of National Conference on Industrial Hydraulics, LaSalle Hotel, Chicago, Ill., will feature a Computer Session on Thursday morning, the 27th. For information contact R. J. King, c/o Technology Center, 3300 S. Federal, Chicago 16, Ill.

October 28-29

1955 Philadelphia ISA Section Symposium "Automatic Control Loops—Electronic or Pneumatic?", at the Penn Sherwood Hotel, Phila., Pa. For information write c/o R. F. Eisele, Leeds & Northrup Co., 4907 Stenton Ave., Phila. 44, Pa.

October 31-November 1

International Conference on Scientific Basis of Applied Solar Energy, University of Arizona, Tuscon, Arizona as a prelude to the World Symposium on Applied Solar Energy to be held in Phoenix, Nov. 2-4. For information contact Symposium Headquarters, Suite 204, Mayer-Heard Bldg., Phoenix, Arizona.

November 1-5

SRI, Association for Applied Solar Energy and University of Arizona World Symposium on Applied Solar Energy, Westward-Ho, Phoenix, Arizona. For information write Public Relations Dept., Stanford Research Institute, Stanford, Calif.

November 3-4

Eighth Annual Electronics Conference sponsored by the Kansas City Sec. IRE, Town House, Kansas City, Kan. For information write P. O. Box 391, Kansas City 41, Missouri.

November 3-4

Fourth Annual Louisiana Polytechnic Institute Instruments Conference, Ruston, Louisiana. For information write School of Engineering.

November 7-9

Eastern Joint Computer Conference and Exhibition sponsored by AIEE, IRE and ACM, Hotel Statler, Boston, Mass. For information write Box 223, Boston 1, Mass.

November 9-11

Nineteenth Annual Time and Motion Study and Management Clinic, Sherman Hotel, Chicago, Ill. For information write Industrial Management Society, 35 E. Wacker Dr., Chicago 1, Ill.

November 13-18

American Society of Mechanical Engineers' 75th Annual Meeting. Hotel Congress, Chicago, Ill.

November 14-17

Second International Automation Exposition will be held at Chicago's Navy Pier. For information write The Second International Automation Exposition, 845 Ridge Ave., Pittsburgh 12, Penna.

November 16-18

Society for Experimental Stress Analysis meeting and exhibit, Hotel Sheraton, Chicago, Ill. For information write J. J. McDonald, Consolidated Engineering Corp., 919 N. Michigan Ave., Chicago, Ill.

November 17-18

Tenth Mid-West Conference of American Society for Quality Control, Schroeder Hotel, Milwaukee, Wis. For information contact R. H. Byrnes, 3402-A N. Humbolt Ave., Milwaukee, Wis.

November 28-30

Professional Group on Instrumentation, Atlanta Sec. of I.R.E. Instrumentation Conference, Biltmore Hotel, Atlanta, Ga. For information contact D. L. Finn, School of Electrical Engineering, Georgia Institute of Technology, Atlanta, Ga.

January 9-10

Second National Symposium on Reliability and Quality Control in Electronics, Hotel Statler, Washington, D. C. For information contact V. Wouk, Beta Electric Corp., 333 E. 103rd St., New York 29, N. Y.

January 19-21

Dallas-Fort Worth Chapter of IRE Professional Group on Electronic Computers National Simulation Conference, Dallas, Texas. For information contact J. R. Forester, 2104 Huntington, Arlington, Texas.

March 19-23

American Society of Tool Engineers' Industrial Exposition, Chicago International Amphitheatre, Chicago, Ill. For information contact ASTE Industrial Exposition, 10700 Puritan Ave., Detroit 38, Mich.

April 26-27

American Institute of Electrical Engineers National Meeting, Bradford Hotel, Boston, Mass. For information write E. T. Davis, Leeds & Northrup Co., 4901 Stenton Ave., Phila. 44, Penna.

May 21-25

Forty-first National Conference on Weights and Measures will be held in Washington, D. C. For information contact National Bureau of Standards, U. S. Department of Commerce, Washington 25, D. C.

June 17-22

Twelfth Exhibit of Testing and Scientific Apparatus and Laboratory Supplies will be held at Atlantic City, N. J. For information contact Fred F. Van Atta, American Society for Testing Materials, 1916 Race St., Phila. 3, Pa.

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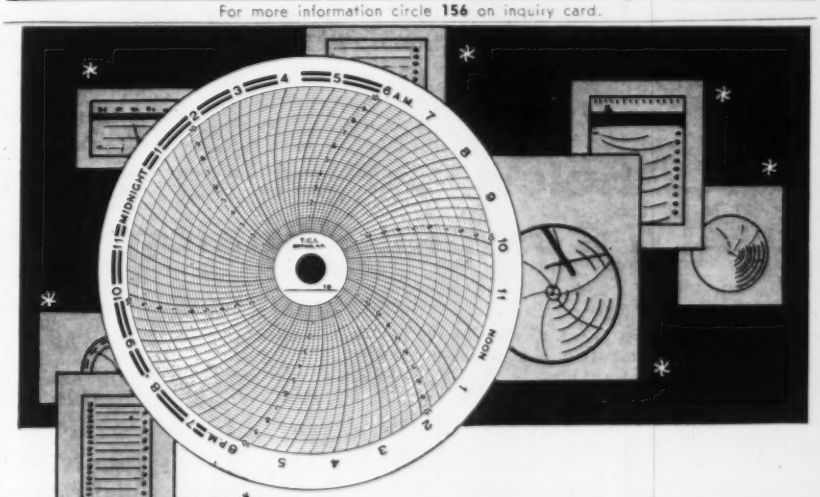

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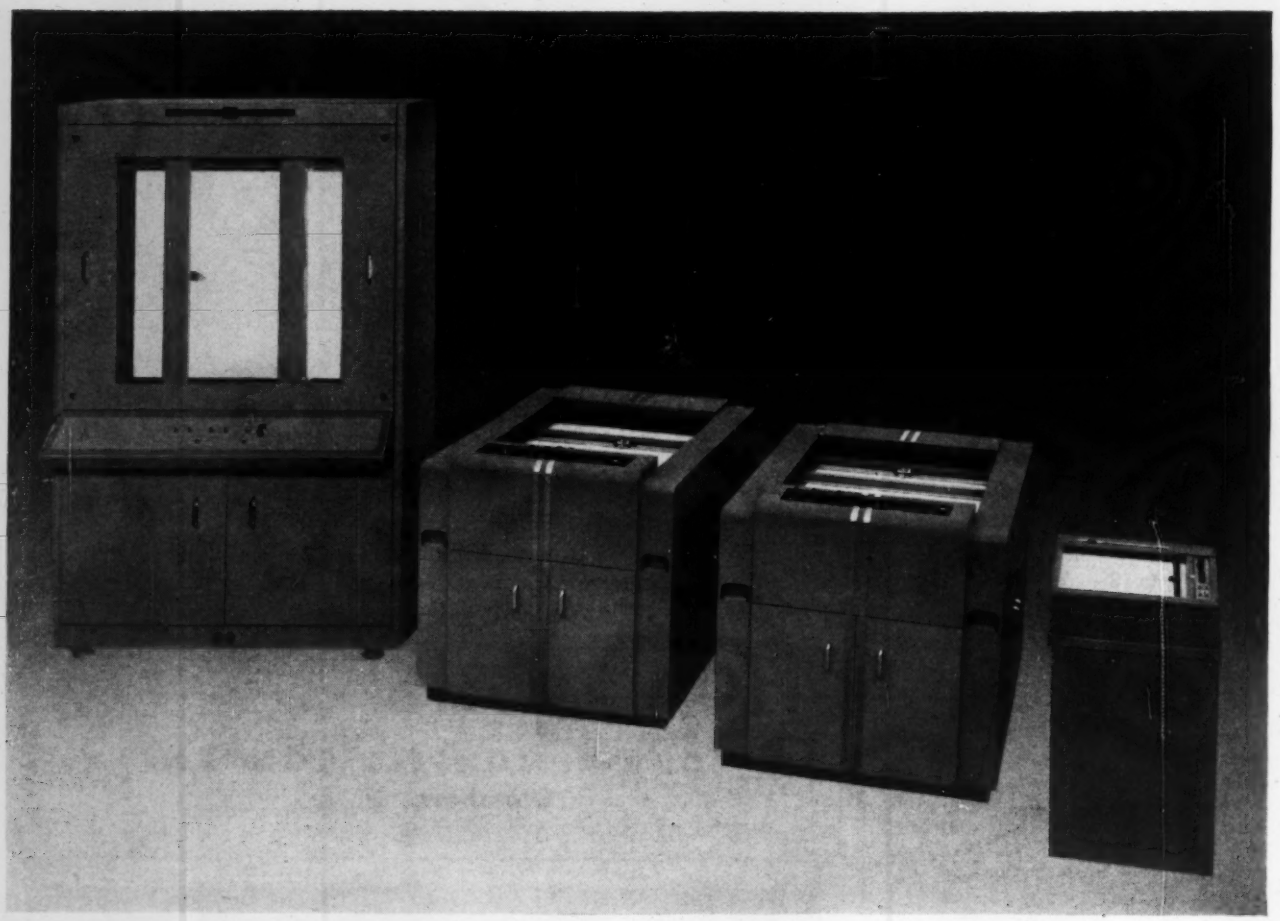

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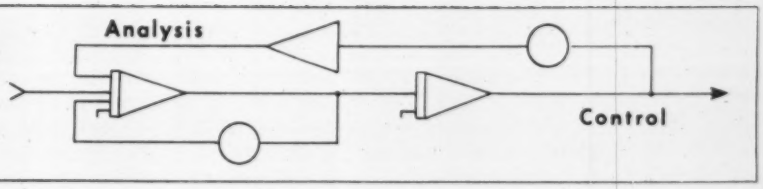
The SIMULATION COUNCIL Newsletter



John H. McLeod, Jr., EDITOR

Suzette McLeod, SECRETARY

Western Simulation Council
Norman L. Irvine, Aerojet-General Corporation, Azusa, Calif.; Chairman, Steering Committee.

Midwestern Simulation Council
R. R. Weber, Cincinnati Milling Machine Co., Cincinnati, Ohio; Chairman, Steering Committee.

Eastern Simulation Council
Harold K. Skramstad, National Bureau of Standards, Washington, D.C.; Chairman, Steering Committee.

Southeastern Simulation Council
See Information (without theory)

Bits

We have so many interesting things to say this month that your Editor will forego his usual two-bits' worth and devote his efforts to (1) abstracting the comments of an engineer-president, an economist, a representative of the Junior Chamber of Commerce, and a labor representative at a recent Industrial Analysis and Control Council panel discussion of "Possible Effects of Automation On Our Way of Life" (sent to me by Stuart Schy of Librascope); and (2) condensing the report by Ro Favreau (Electronic Associates) of the Eastern Simulation Council meeting on "Electronic Analog Multiplication."

Sorry I had to do the abstracting and condensing as both stories were interesting in full, but we don't want you guys and gals to go away tired of reading before you get the full word.

Pieces

INDUSTRIAL ANALYSIS & CONTROL COUNCIL PANEL DISCUSSION "POSSIBLE EFFECTS OF AUTOMATON ON OUR WAY OF LIFE"

This panel was organized by *Stuart Schy*, sponsored by the University of California at Los Angeles Department of Engineering, and held on the UCLA campus the afternoon of 20 April 1955.

Imm On Engineering and Managerial Implications

Lewis Imm, president of Librascope, was the first panel member to be introduced by *Bill Waddell* (Giannini DATEX Division, Pasadena, Calif.) the moderator. Explaining that areas of Librascope development now cover analog and digital, mechanical, electronic, and magnetic products for automation, Mr. Imm said that though young men entering college may think the engineering field will be overcrowded, that just isn't true. "I will take any of them that want a job four years from now under contract today!" he said, and continued, "I can't see how machines are going to displace engineers. We are not getting enough of them as it is."

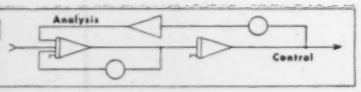
"The real problem is to enable fewer engineers to handle more work. The type of work we want engineers to do is creative thinking, not routine jobs. Automation should help."

Problems involving the use of atomic energy and heat transfer and things of that nature require long equations, some of which actually can't be solved by ordinary means of computation, but machines now being produced can solve them. The solution of such problems will make possible projects which were impossible before, such as the exploitation of atomic energy for civilian use, and the production of certain new medicines and vitamins which require automatic process control.

Managerial control should be greatly aided by the use of computers and data-handling systems. The information needed for managing a business properly will be available much faster, and in better form than has ever been possible in the past. As an example, the collection of costs for individual parts has seldom been economically justified because the information was not available for four to six weeks after a run. We now visualize systems by which costs can be collected automatically so that after lunch the production department can have the costs of all operations performed that morning. This type of information will not only make the manager more effective, but will encourage him to plan and control his operations more carefully.

Kircher On The 5 R's

Bill Waddell next introduced *Dr. Paul Kircher*, Assistant Professor of Accounting, UCLA. "Automation," said Dr. Kircher, "Cuts across so many fields that to understand what is happening, one must examine the field in general." To determine areas in which automation is really going to take hold Dr. Kircher uses a gim-



mick: five words beginning with "R": *Risky*—Remote installations like atomic energy plants or coal mines are likely prospects for automation. *Remote*—Remote control, of oil wells and missiles for instance, requires automation. *Repetitious*—Tiresome repetitious jobs invite automation. *Rapid*—Dr. Kircher referred to Norbert Wiener's "using the interstices of human time" (the little bits of reaction time that you just can't use human-wise in order to get the response required) as in guided missiles. *Readjustment*—Need for continual readjustment, as in process control.

Dr. Kircher does not expect the large manufacturer with automatic equipment to turn out one standard product. He believes the reverse will happen—with the properly designed automatic equipment, a big manufacturer may end up with a more flexible operation than the smaller one.

We are told that we need not fear automation because although machines will eliminate some jobs, other jobs will be created by those selfsame machines. This is true. There will no longer be need for the many girls now typing bills and keeping books in offices; however, new jobs of operating and servicing computers will be created. But, asked Dr. Kircher, will the typers of bills and keepers of books have the talents necessary to operate and service computers, even given the proper training?

Richardson On The Small Businessman

Robert K. Richardson, California state vice-president of the Junior Chamber of Commerce, was the next speaker introduced. Discussing the impact of automation on the young business man, Mr. Richardson said that whereas industry worries about unit cost, the farmer about weather, and the minister about souls, the small business man worries about customers.

"This gives rise to my first concern about automation. Automation depends to a great degree upon electric power. Give a manufacturer advantageous electric rates in a certain area, and he will locate his factory there, hire labor, and the small business man in that area will have customers. But what about the small business man in other areas? Will automation result in a mass exodus of his customers?

"My second concern involves technical aspects. Few small business men can afford the research necessary to take advantage of automation, nor can they afford to hire consultants. What help can they expect from the automation equipment manufacturer?

"My third concern is with the displacement of labor. The small business man does not in general earn his living from the small group of well-paid technical personnel. His major concern is the mass labor force. Will they be displaced so rapidly that small business too will suffer?

"My fourth concern is with my taxes. Automation will require that many workers upgrade themselves with more training. Who will pay for this training? Individual managements? The unions? Or we taxpayers? Must we help pay for automation by building and staffing new schools and training centers?

"My fifth and last concern is with advertising and selling costs. Undoubtedly automation will increase production, reduce cost, and improve quality. Advertising and selling are going to have one whale of a job to keep up with the efficiency of this productive monster. For every dollar spent on automation, it makes sense to me to set aside some money to invest in sales manpower and advertisement that will assure full disposition of plant output.

"So even if the small business man is able to automate with his limited economic resources, he still hasn't licked the problem. His resources will be gone and he still must advertise and sell. It looks as if those who have will get—those who have not may die on the competition vine of automation."

Schrade On Labor

Paul Schrade, speaking for the United Auto Workers, CIO, presented a statement which read in part as follows:

The first Industrial Revolution made possible enormous increases in the living standards of the peoples of the industrialized nations. But, in the absence of responsible social policies, these gains were bought at an awful price in economic dislocation, social injustice, and human misery.

Now we enter the second phase of the industrial revolution and the potential impact of automation—for good or evil—presents us with problems and prospects comparable to those confronting mankind at the dawning of our industrial civilization. Therefore, automation must be met sanely and constructively so that the miracle of mass production—and the ever greater economic abundance made possible by automation—can find expression in the lives of people through improved economic security and a fuller share of happiness and human dignity.

Historically, the problems of mankind have been set in conflict between people, groups and nations, each engaged in a struggle to divide up economic scarcity. We have had a world divided between the "haves" and the "have-nots". *Now* science and technology have at last given us the tools of economic abundance, and we are confronted no longer with the need to struggle to divide up scarcity.

The UAW-CIO and its one and one-half million members welcome automation, technological progress and the promise of the peacetime use of the power of the atom. Our goal will not be achieved, however, if we put our trust in luck or in blind economic forces. Nothing is accomplished by a studied refusal to admit that a problem exists, accompanied by accusations of "scare-mongering" against those who state the problem in order to stimulate the search for a solution.

In the long run, society will no doubt adjust itself to the change, just as it did some generations after the beginning of the first Industrial Revolution. But labor is not willing to buy an eventual boost in living standards for all at the cost of any such prolonged suffering as followed the first Industrial Revolution.

"The long run", in Reuther's view," . . . is not the consideration, for, as Lord Keynes once said, in the long run we are all dead."

As the CIO has declared: Effective action to increase mass purchasing power must be taken on all possible fronts. Negotiation of guaranteed wage plans will help to maintain living standards and stabilize employment.

A generous sharing of our potential abundance with the under-privileged peoples of the world will not only help to provide outlets for increased production, but will directly support and strengthen our friends and allies throughout the free world in their fight against Communism.

EASTERN SIMULATION COUNCIL MEETING

Subject: Electronic Analog Multipliers

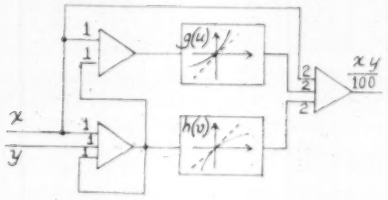
Dr. Leonard Pode, representing the David Taylor Model Basin in Washington, D. C., was host for the meeting of the Eastern Simulation Council held on 16 May 1955.

Loveman On Reeve's Multiplier

The first speaker was *Bernard Loveman* (Reeves Instrument Corp., New York, N. Y.). His topic was Reeves' Quarter Square Multiplier, which works on the principle:

$$xy = \tfrac{1}{4}[(x+y)^2 - (x-y)^2]$$

Though this principle has been used by many people, the actual circuit has some unique features:



$$\text{where: } g(u) = \frac{u^2}{200} + u$$

$$h(v) = -\frac{v^2}{200} + v$$

$$g\left(-\frac{x-y}{2}\right) = \frac{x^2 - 2xy + y^2}{800} - \frac{x-y}{2}$$

$$h\left(-\frac{x+y}{2}\right) = -\frac{x^2 + 2xy + y^2}{800} - \frac{x+y}{2}$$

Therefore, the output is:

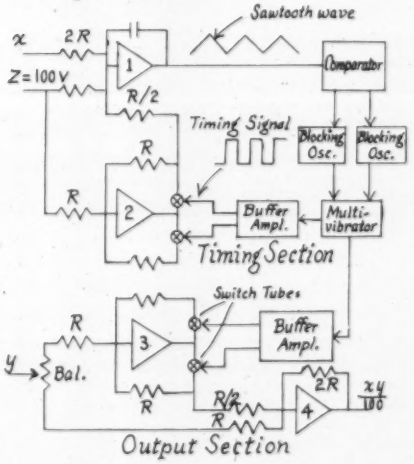
$$-2x - \left(x^2 - \frac{2xy}{400} + y^2\right) + (x-y) + \left(x^2 + \frac{2xy}{400} - y^2\right) + (x+y) = \frac{xy}{100}$$

The particular functions g(u) and h(v) were used because they were easier to generate than an actual square-law curve. For the square law there is zero slope at the origin, whereas the g and h functions have unity slope at the origin. Twenty diode sections were used to generate each nonlinear function. Bernie stated that the features of this type of multiplier are (1) Simple circuitry (only amplifier and diodes are used). (2) Flexibility (amplifiers are regular computing amplifiers). (3) Reliable operation (no wearing of parts). (4) Ease of calibration (the only elements subject to change are the nonlinear functions. These are calibrated by having a voltage divider introduce a group of known input voltages and a group of corresponding required outputs of the nonlinear-function generators. The various diode sections can then be adjusted for zero error.) (5) Accuracy (curves presented showed error to be less than 0.20 volt.) (6) Excellent dynamic performance (Again, curves presented showed essentially flat response up to 100 cps and a phase shift of about ¼ degree at this frequency with x held constant and y a sine wave. (7) Amplifier-type output.

In answer to questions, Bernie pointed out that 6H6 diodes (aged for 200 hours) were used in the nonlinear-function generators with the filament voltage regulated at 10% below 6.3 v. The calibrating procedure takes care of any differences caused by diode replacement. The diode capacity is the main limitation to frequency response. The zero point is most accurate because no diodes cut in here and the slopes are linear. The output noise with both inputs grounded is about 10 millivolts.

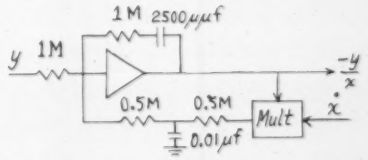
Stark On Goodyear Multiplier

Mr. Stark (Goodyear Aircraft Corporation, Akron, Ohio) then described the Goodyear Time Division Multiplier, which generates a square wave with amplitude proportional to one variable, y, and with division of positive and negative amplitude proportional to the other variable, x. This is accomplished with the following circuit:



In the timing section, for x = 0, amplifier 1 integrates down until the voltage into the comparator equals minus 20 volts. At this time the comparator triggers the blocking oscillator, which changes the state of the multivibrator. The multivibrator, through the buffer amplifier, turns on the upper switch tube of amplifier 2. This now introduces minus 2 z into amplifier 1 and changes the direction of integration. The upper switch of amplifier 2 is turned off when the output of amplifier 1 reaches –5 volts. Thus a balanced square-wave is generated. If x assumes a positive or negative value, a different type of square wave is generated which follows the equations defining T_1 and T_2. The output of this timing section is then used to control the y signal in the output section.

Paul Hurney (Dynamic Analysis & Control Laboratory, MIT, Cambridge, Mass.) asked whether this multiplier could be used as a divider by varying z. Mr. Stark gave the following dividing circuit:



Mr. Stark further stated that maximum drift was 0.02 volt per day, and accuracy was within 0.2 volt. The phase shift was less than 8 degrees at 200 cycles. The noise output is about 100 mv at the repetition frequency of 15 kc.

Gunther Martin (Schlumberger Instrument Co., Ridgefield, Conn.) asked whether there was provision for varying the output filter required to obtain the average. Mr. Stark indicated that the output filter, which is located in the feedback of the output amplifier, is fixed.

McCool On NRL AM-FM Multiplier

Mr. McCool (Naval Research Laboratory, Washington, D.C.) then told of an AM-FM-type multiplier, the basic ideas of which were developed at NRL and described in the October 1953 issue of the *IRE Proceedings*. A commercial version of this type of multiplier is being constructed by the Mid-Century Instrumatic Corporation.

In this multiplier the amplitude of a carrier is made proportional to one input variable while the frequency is controlled by the other. Suitable demodulation yields the product.

The arrangement is similar to that found in any ordinary FM receiver,

where the discriminator output is a function both of the frequency deviation and the amplitude level which is controlled by the limiter. If the frequency deviation is doubled, the output of the discriminator is doubled. If the level of the limiter is doubled, the output of the discriminator is also doubled. If both are doubled, the output of the discriminator will be four times as large.

The characteristics of this type of multiplier are:

Carrier Frequency—1500 kc; Frequency response about 6° phase shift at 500 cps for the x channel, and about 4° phase shift at 500 cps for the y channel; Accuracy and drift, less than 0.2 volt. The basic limitation on accuracy is the matching of discriminators in the follow-up units and the multiplying units.

Davis On BUSAC Multiplier

Mr. Davis (David Taylor Model Basin, Washington, D.C.) then described the BUSAC (Bureau of Ships Computer) and the BUSAC multiplier. The unique feature of the BUSAC computer is the input function generator, a drum of 120″ circumference, upon which are drawn in sequence half sections of a ship representing various stations between the bow and stern. This drum rotates about 1 cps and the output signal is fed into a function control unit which generates the other half section. This unit also cuts off the various sections at the water line, taking into account the roll of the ship. The signals from the function control unit are operated upon by conventional analog computing equipment to determine various ship characteristics.

The BUSAC multiplier uses a technique called the "Theory of Difference in Magnitude Methods," described by:

$$k E_1 E_2 = Av [| E_1 + E_2 + E_c| - | E_1 - E_2 + E_c |]$$

where E_c is a carrier signal which has a linear slope (in this case, a triangular wave was used). The above equation holds provided that $|E_1 + E_2| \leqq |E_c|$. Five chopper-stabilized amplifiers were used to solve the equation, as shown in the circuit at the bottom of this page.

Actually, the process is similar to the time division multiplier. Instead of having square waves, however, the output of A5 is a triangular wave, the amplitude of which is controlled by one of the variables while the width of the positive and negative sections are controlled by the other variables.

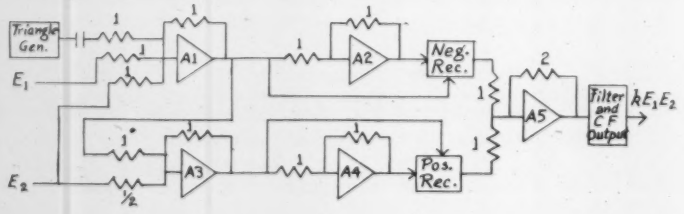
The characteristics presented for this multipler are: Accuracy—better than 0.07% of full scale; Stability—better than 0.08% of full scale; Precision—better than 0.1% of full scale; Phase shift at 200 cycles—10°; Output voltage—about 37 v; Noise level—about 7mv.

Mr. Davis had an excellent report on this multiplier titled "A General Purpose Electronic Multiplier," by Robert A. Meyers. This no doubt could be obtained by writing to the David Taylor Model Basin.

Mr. Butler of Goodyear Aircraft wondered if anything concrete had been done using logarithmic summing for multiplication.

Dr. Pode indicated that servo-type multipliers were fine with respect to speed for the applications at DTMB; however, his main complaint was the amount of linear equipment required for unloading. Electronic multipliers do not help in this respect because each channel requires quite a bit of equipment. He suggested that a multiplier based on asynchronous time-division of both variables might offer a way of reducing costs.

Thyrite resistors were mentioned, but no one present indicated any enthusiasm or good experience. *Howard Wright* (National Bureau of Standards, Washington, D. C.) suggested that possibly a semi-conductor may be developed which has a good exponential characteristic. There were no comments from the group; how about some from you?



INFORMATION (Without Theory)

All readers in South Eastern and South Central U. S. take note: We have a letter from *W. K. McGregor* of ARO, Inc., Tullahoma, Tennessee, which reads in part ". . . regarding formation of a Simulation Council in the Southeast . . . I have contacted people in this area who are interested in simulation and have about 80 statements of interest. *An initial meeting has been planned for September 30, 1955 at the Arnold Engineering Development Center, Tullahoma, Tennessee.*"

So it looks as if a Southeastern Simulation Council is in the offing. We shall watch their progress with interest, and help all we can because we still have lots to learn—and every Council so far has stimulated additional interest and made welcome contributions to our general fund of knowledge. Good luck, Southeastern Simulation Council!

Thots (to forget about)

"Work is the curse of the drinking classes."

Oscar Wilde

Anyone for simulatin' their stimulation?—or stimulatin' their simulation?

Computer Events

other events on page 1500

Southeastern Simulation Council
Date: Friday, 30 September 1955
Place: Arnold Engineering Development Center, Tullahoma, Tennessee
For further information get in touch with W. K. McGregor, ARO Inc., Tullahoma, Tennessee. And see Information (without theory).

Western Simulation Council
Date: Thursday, 10 November 1955
Place: Beckman Instrument Co., Fullerton, Calif.
Subject: "Simulation with a Human in the System"

Eastern Joint Computer Conference
Dates: 7-9 November 1955
Place: Hotel Statler, Boston, Mass.
Subject: "Computers in Business and Industrial Systems". Chairman of the program committee, Dr. I. Travis, Burroughs Corp., Paoli, Penna.

Second Computer Clinic
Dates: 15-17 November 1955
Place: Navy Pier, Chicago, Ill.
Feature: Six 2-hour demonstrations and lectures on various computers. Fee is $5.00. For registration; 2nd Automation Exposition, 845 Ridge Ave., Pittsburgh 12, Penna.

Fig. 1. Laboratory version of circuit power supply and indicator.

Fig. 2. Location of components on circuit chassis.

3C24 IONIZATION GAGE

A standard 3C24 power triode has been converted to a rugged ionization gage for services not requiring extreme accuracy. Gage, circuit, and calibration are described, after a valuable review of vacuum-measuring technique and vaccum units.

LOREN E. BOLLINGER
The Ohio State University

VACUUM devices in industry and the laboratory operate over a range of pressures so large that it is wishful thinking to expect any one pressure-measuring instrument to span the whole scale. Accordingly, it has become common practice to use a number of basically different instruments to detect pressures from atmospheric to 10^{-9} mm of mercury. The instruments commonly used are the manometer, McLeod gage, thermocouple gage, Pirani gage, Philips gage and the ionization gage.

Each type of instrument has desirable characteristics in some interval between atmospheric and very "hard" vacuums. Selection of a basic measurement system is made after consideration of the following factors: (1) range of pressures to be covered, (2) required accuracy, (3) type of gas, (4) frequency response, (5) stability and calibration, (6) physical location and environmental influence, (7) frequency of measurement, (8) inherent errors of system, (9) pressure-output signal relationship and presentation, and (10) cost.

The ionization-gage type of low-pressure transducer covers an extremely wide pressure range and is practically the only type suitable for measurements below 10^{-5} mm Hg. This article discusses some of the characteristics of the ionization gage, and presents the circuit of a gage constructed for use on a laboratory vacuum system.

Pressure Units

Engineers associated with high-vacuum equipment in the United States generally use either the micron or the millimeter (mm) of mercury (Hg) as basic units of vacuum measurement. Terms such as "28 inches of vacuum" or "3 pounds per square inch" may be satisfactory for power-plant equipment, but it should be remembered that "high vacuum" is quoted in pressure units only. A physical intepretation of the unit "mm of Hg" as applied to a vacuum system can be obtained by imagining that a barometer tube is placed inside the high-vacuum device. Thus the height of the column of mercury then becomes a measure of the system pressure. A perfect vacuum would result in zero column height.

Pressures greater than one thousandth of a millimeter of Hg are usually expressed in microns. A micron equals 0.001 mm of Hg; so a pressure of 7 microns equals 0.007 or 7×10^{-3} mm. Below a pressure of one micron, decimal fractions of a millimeter of mercury are used. If the

Table 1.—Pressure-unit Conversion Factors

Pressure Unit	*To obtain mm of Hg multiply by*	*To obtain microns multiply by*
Millimeter of Hg	1	10^{3}
Micron	10^{-3}	1
Dyne/cm^2	7.50×10^{-4}	0.750
Gram/cm^2	0.736	736
Kilogram/m^2	7.36×10^{-2}	73.6
Pound/inch^2	51.7	5.17×10^{4}
Pound/foot^2	0.359	359
Atmosphere	760	7.60×10^{5}
Barye	7.50×10^{-4}	0.750
Microbar	7.50×10^{-4}	0.750
Tor	1	10^{3}

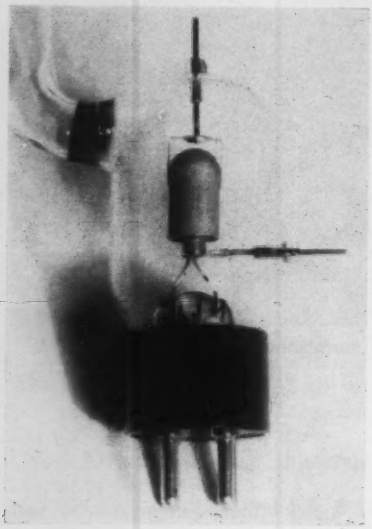


Fig. 3. 3C24 triode power amplifier can be converted into a rugged ionization gage by attaching graded seal.

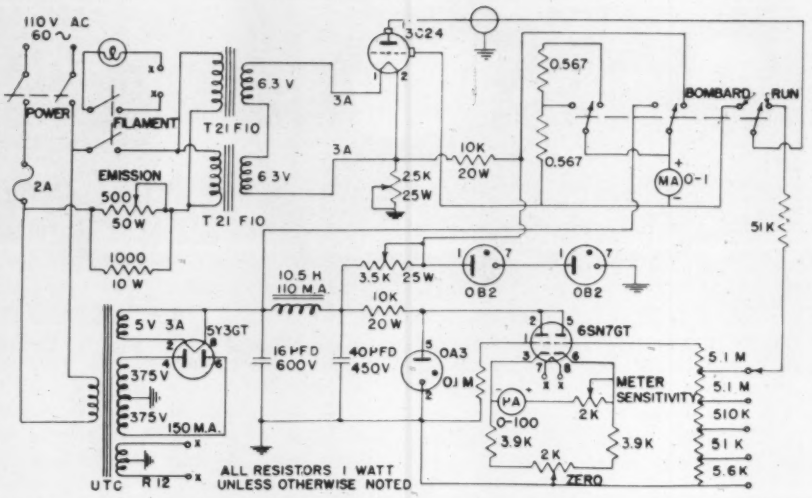


Fig. 4. Circuits for power supply and ion-current indicator for use with the 3C24 ionization gage. VR-tube-regulated 216-v supply is provided for the 3C24 grid and filament; adjustable 12-v a-c supply for the filament. Ion current is indicated on 100-microampere indicator between cathodes of 6SN7 cathode-follower-type vacuum-tube voltmeter.

pressure were 5 x 10^{-6} mm of Hg, it is equivalent to saying that the mercury column in the barometer-tube analogy mentioned would rise only 0.000005 mm.

Various systems of pressure units are used in other countries as well as in the several fields of the physical sciences. The physicist may work with dynes/cm^2, while the engineer deals with psi. Foreign scientific literature contains terms unfamiliar to us. Table 1 provides factors for convenient conversion from one system of units to another.

Ionization-gage Theory

The triode ionization gage is, by far, the most commonly used vacuum gage for pressures lower than 10^{-4} mm. A useful range of from 10^{-3} to 10^{-9} mm of Hg can be covered with a single instrument. The tube is similar to an ordinary triode used in an amplifier. Tubulation from the glass envelope of the tube is sealed into the vacuum system—usually by fusing the glass tubing together. In a metal vacuum system a glass-to-metal connection known as a Kovar seal is often used. (In a Kovar seal the glass is fused to the metal forming a perfect seal; the metal is an alloy selected to have a coefficient of temperature expansion very close to that of the fused glass.)

Connection of the tube elements in the electrical circuit is, however, unconventional—a high positive voltage is placed on the grid, while the plate is operated at a low negative potential relative to the filament. Hence the grid collects all the electrons emitted from the filament (Fig. 4). Tubes with cathodes are not usually used because the surface tends to become poisoned by destructive action of certain gases. Another departure from convention is that the filament is operated in a temperature-limited condition rather than space-charge limited. The conventional cloud of electrons (space charge) is not allowed to form just off the surface of the filament. This feature necessitates operating the filament at a reduced voltage so that the emission can be temperature-limited. Tube characteristics are quite different under temperature- and space-charge-limited conditions.

Electrons boiled off from the hot filament are attracted to the positive grid of the ionization tube. As the grid is a helix of wire rather than a large continuous surface, a high percentage of the electrons will miss the grid on their first pass. The electrons missing the grid will be thrown towards the plate by their momentum. However, the electrons are repelled because of the negative operating potential of the plate. Again the electrons attempt to collide with the grid; the probability exists that some of of the electrons make several of these grid-to-plate-to-grid oscillations before a collision with the grid is obtained.

If gas molecules from the vacuum system are in the tube, the electrons may ionize a few of the molecules during flight. As soon as a positive ion is formed, attraction occurs between the ion and the negative plate. If one can detect the positive-ion plate current, a measure of the system pressure is available because the number of ions formed during collisions of the molecules and electrons is proportional to the pressure; *the plate current is a linear function of the pressure for a constant value of electron emission from the filament.*

Calibration

The usual procedure is to adjust the filament emission to some selected value and calibrate the plate current as a function of pressure while holding the filament emission constant. A McLeod gage is most useful for the calibration technique. Calibration of the McLeod gage does not depend on the nature of the gas so long as it obeys Boyle's Law; bulb and capillary geometry alone determine its calibration. However, McLeod gages cannot give continuous indication of pressure, and condensable vapors in the vacuum system can cause error in pressure measurement with the McLeod gage.

Operational Considerations

Gases such as oxygen, hydrogen, and carbon dioxide should not be used in a vacuum system having an ionization-gage transducer. The hot filament causes decomposition, or pyrolysis; serious damage or complete destruction of the filament follows. The two major advantages of the ionization gage are (1) continuous reading and (2) quick response to pressure changes.

At extremely low pressures errors can be introduced by the liberation of gas from the walls and electrodes of the tube. Positive ions bombard the plate and tube walls,

causing surface molecules to break loose. At very low pressures these extra molecules become an appreciable fraction of all the free gas molecules present in the tube. A flame can be used to heat the glass wall and "degas" the tube. Gas in the plate element is removed by connecting the plate to the grid (electrically) and bombarding the plate with electrons. Of course, the grid also is degassed by this procedure. Care must be taken that the grid current does not exceed its maximum value. At low pressures the mean free path of the gas molecules becomes very large. If the tubulation from the vacuum system to the gage is too long or too small in diameter, equilibrium between the pressure in the tube and system cannot be maintained. The gage tube should be located close to the vacuum system to minimize equilibrium time.

An increase in grid potential results in an increase of ion current to the plate. However, the ion-current—grid-voltage relationship is not linear. A phenomenon similar to saturation in a regular vacuum tube takes place. The grid voltage is maintained constant in most ionization-gage pressure detectors. Thus, with the filament emission fixed and the grid voltage constant, the only remaining problem is to measure the ion current to the plate. A sensitive galvanometer can be used but is inconvenient to read; in addition, the galvanometer can be damaged easily. Therefore, some type of electronic amplifier or bridge circuit usually is employed to detect the ion current.

3C24 Ionization-gage Tube

Ionization-gage tubes are specially designed and fabricated for commercial vacuum-measurement equipment. Usually, these tubes are delicate and can be ruined by improper care or procedure. Many times the need arises for a rugged high-vacuum detector wherein the utmost in sensitivity is not required. It is possible to use ordinary radio-type tubes for this purpose. We have found that the 3C24 triode has desirable properties. The filament is sturdy and the tantalum plate can be heated by electron bombardment until the element glows bright red. This extreme temperature facilitates degassing the tube. Fig. 3 shows a 3C24 tube which has been modified in preparation to sealing it into a vacuum system.

A hole is blown into the side of the glass envelope and a *graded seal* fused to it. The graded seal provides a series of glasses whose coefficients of thermal expansion differ from each other by only a small amount; a sufficient number of glass types are used in the seal to go from the expansion coefficient of the soft glass envelope to Pyrex or whatever type of glass tubulation is required. If the Pyrex tube were sealed to the soft glass envelope directly, the seal would crack upon cooling because of the large difference in coefficients of thermal expansion. The top pin on the tube connects to the plate; the grid electrode is brought out the side of the envelope; filament leads are connected to the base pins.

Control and Detection Circuit

A schematic diagram of the power supply and ion-current measurement bridge is shown in Fig. 4. The conventional full-wave-rectified high-voltage supply provides positive potentials for the grid and filament of the 3C24 tube; voltage regulator tubes are used to maintain a constant 216-v supply for the grid. Two six-volt filament transformers in series supply the 12-v filament supply for the gage tube. A series rheostat in the transformer primary permits the electron emission from the filament to be varied.

Connection to the plate is made with a shielded cable to minimize stray pick-up. The ion current (from the plate) flows through a series of resistors producing a voltage drop proportional to the pressure.

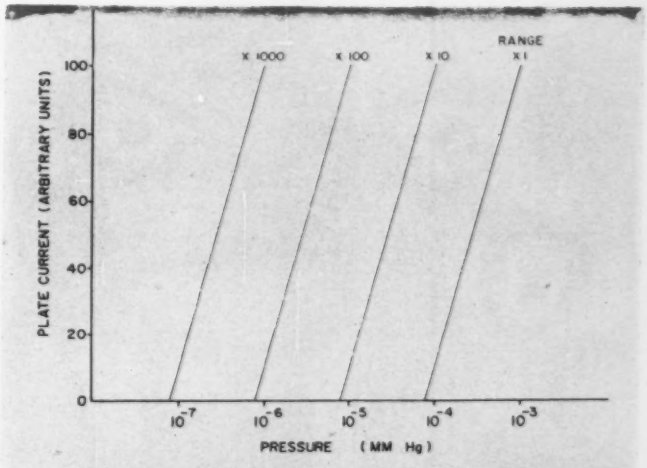


Fig. 5. Typical calibration curve obtained with the 3C24 tube (with fixed emission current and grid potential).

A 6SN7 tube is used in the indicator circuit, which is a conventional vacuum-tube voltmeter. When no ion current flows, the zero-adjust potentiometer is set to balance the 6SN7 cathode potentials. Voltage developed by the ion current causes one cathode potential to vary, and the signal is detected by a 100-microampere indicator. A switching arrangement provides different VTVM sensitivities. The meter-sensitivity rheostat can be used to adjust the meter to a particular value when the ionization-gage tube is calibrated against a McLeod gage or other reference standard.

Operation

Two views of the unit are shown in Figs. 1 and 2. Vacuum measurements are made when the control switch is in the RUN position. Degassing is accomplished by changing to the BOMBARD position and increasing the emission control until the combined plate and grid current is of the order of 100 ma. The gage-tube elements will glow cherry red during this operation. After one or two minutes, vacuum measurements can be resumed. The sensitivity control is set to give a suitable deflection on the 100-microampere indicator. Pressure in the vacuum system is obtained by referring to the calibration chart for the particular meter reading and sensitivity range.

The general type of calibration curve obtained with this tube is shown in Fig. 5. A straight-line relationship is obtained for each sensitivity setting of the bridge circuit. Naturally, different curves will be obtained for other grid potentials or emission currents. Bridge unbalance readings must be obtained for the same grid voltage and emission current as used in the calibration procedure in order to correctly interpret the pressure in the vacuum system.

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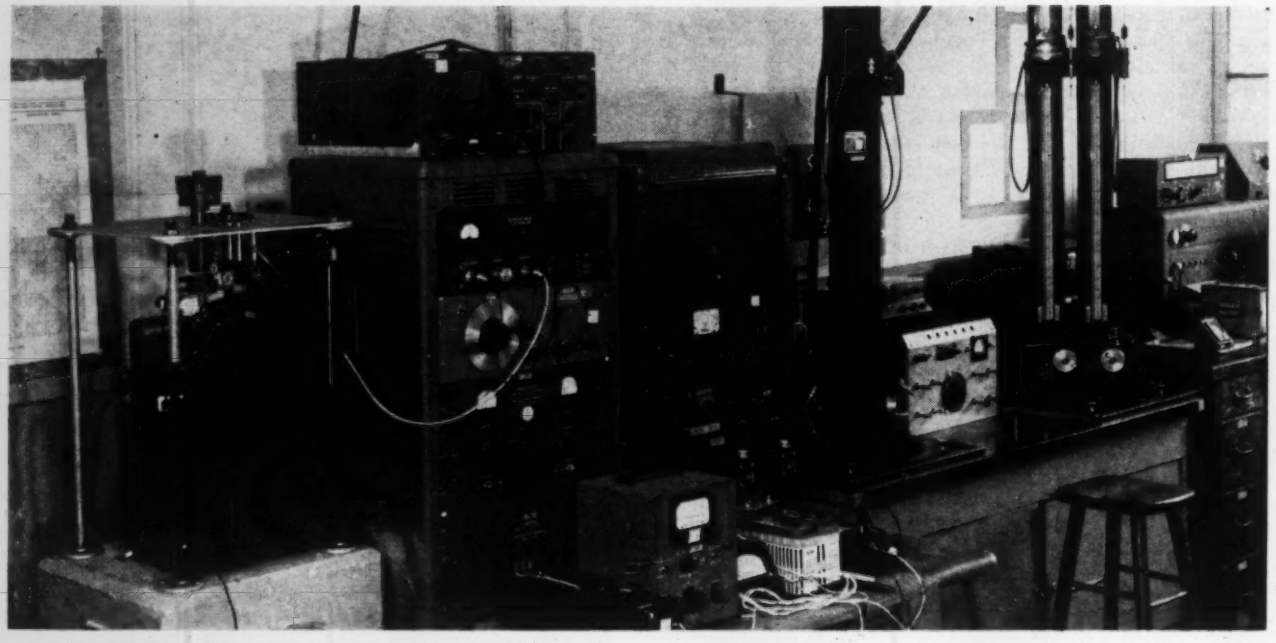

Fig. 1. The Calidyne Optical Displacement System, which uses a back-illuminated 0.001-inch slit mounted under the work plate, is shown at the left. Magnifier on frame focuses image of slit on ground-glass vertical screen (see Fig. 2), ruled in increments of 0.001 inch. The advantages and disadvantages are discussed in the text.

Microscope Technique for ACCELEROMETER

ALVIN B. KAUFMAN and PAUL R. MITCHELL

ACCELEROMETERS are calibrated dynamically by means of a shaker driven at a known frequency and amplitude. Although frequency can be determined easily to a high degree of accuracy (using either an electronic counter or a calibrated audio oscillator), the amplitude must be observed directly as a motion in inertial space which may be smaller than 0.001". Where accuracies of ± 1% are required, difficulties arise as to the true direction, magnitude, and acceleration waveform of the motion. In addition, the configuration of motion is not necessarily a straight line, as shown by the circular or elliptical paths in Fig. 5, which are observed typical paths.

Five methods of displacement measurement are indicated in the literature[2]. However, many of these have serious defects. In general, an optical method is one of the best suited for measurement of amplitudes encountered up to approximately 600 cps. Since at a given g force, displacement is inversely proportional to frequency squared, it becomes difficult to accurately measure the small displacements above 600 cps. For example, the double amplitude at lg, 600 cps, is less than 55 microinches. For comparison, one wavelength of yellow-orange light is about 23 microinches so that in addition to the obvious difficulties in measuring such a small distance there is a further limit due to the finite wavelength of visible light.

Optical Techniques

There are available commercial optical instruments that can be attached to a shaker for measurement of shake-table displacement. A typical displacement instrument, (Fig. 1) is the Calidyne Optical System, Model 34. This system employs a back-illuminated 0.001" slit mounted under the work platform of the Calidyne Shaker (Fig. 2). A magnifier (approximately 30 power) mounted on the shaker frame focuses a bright image of the slit on a ground-glass screen ruled at intervals equivalent to 0.001" increments. The transverse motion of the slit then appears as a broadening of the bright line against the ruled lines. Unfortunately, the magnifier magnifies the slit width as well as the amplitude of motion, so that no better resolu-

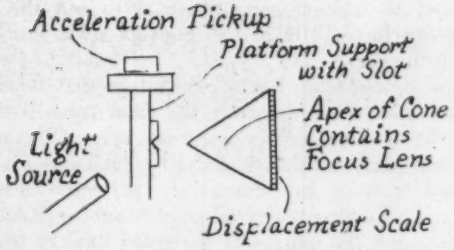

Fig. 2. Principle of Calidyne system.

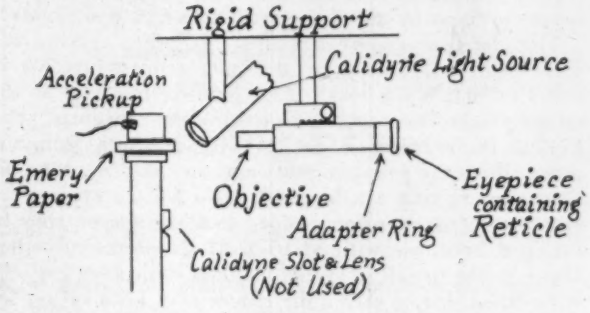

Fig. 3. Principle of microscope installation of Fig. 4.

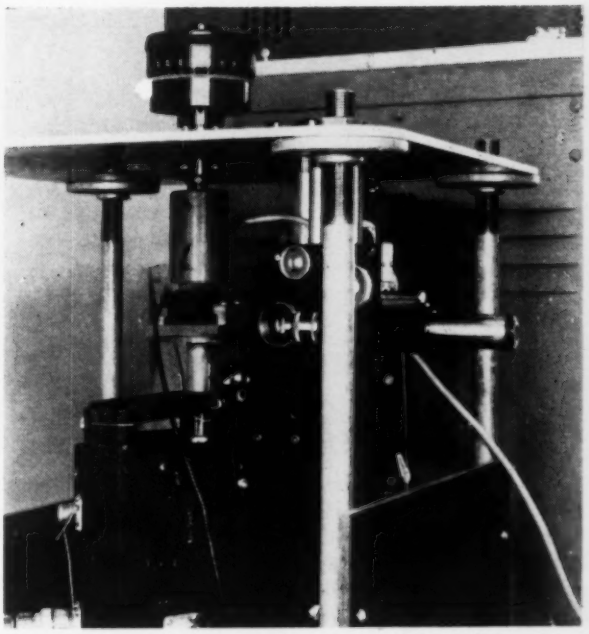

Fig. 4. Close-up view of microscope installation. Accelerometer is on shaker platform, with the emery-cloth reflection-source adjacent. Spacer ring on 40-power microscope achieves the exact magnification required at the image plane of the reticle.

CALIBRATION

Accelerometer calibration requires precise measurement of frequency and amplitude of shaker-table displacement. Disadvantages of available methods are discussed, and new optical techniques using a microscope are presented for the accurate measurement of the displacement.

tion than ± 0.001″ is obtainable, due in part to the granulation and halation inherent in the ground-glass screen. Such an error is equivalent to 2g at 200 cps. The system could be otherwise improved by mounting the viewer on the concrete block instead of the shaker frame to eliminate vibration of the optical mechanism.

Additionally, some improvement in resolution can be gained by using a microscope for viewing the illuminated slit, and still further improvement by substituting an illuminated tightly stretched 0.001″ wire in place of the slit[1]. The latter gives sharp images in the microscope because the wire can be stretched over a dull black background (such as a hole drilled deeply and painted dull black), the black background giving excellent contrast with little glare because a greatly reduced amount of illumination is required.

All of the above systems are inherently incapable of monitoring the shaker sidewise sway. This is a serious deficiency and makes it necessary to look for other means because (1) many accelerometers have appreciable transverse sensitivities (in the order of 5 to 10%) so that sidesway causes an error in accelerometer output, (2) the error due to harmonic content of the vertical motion tends to increase with sidesway, and (3) motion not in line with the vertical causes the true vector force to be different than that measured.

Microscope Techniques

At frequencies up to 600 cps, the displacement amplitude of the shaketable is generally large enough (0.002″, or 2000 microinches, double amplitude at 600 cps, 38g) for precise observation using a high-power microscope[2]. A report to be issued later describes an electronic method suitable for measuring double amplitudes down to 0.00002″ (20 microinches) at frequencies up to 10 kc. At these frequencies a piezoelectric driver is used and the only alternative method of displacement measurement requires the use of an interferometer. However, the distance between interferometer fringe lines is comparable to total displacement at 9 kc, 45g, making the method incapable of high accuracy.

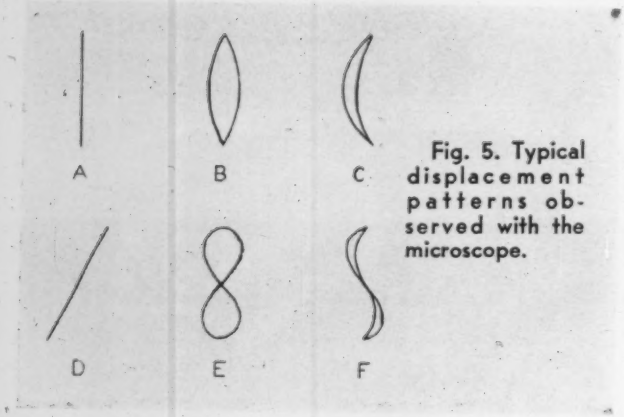

Fig. 5. Typical displacement patterns observed with the microscope.

The two major difficulties to be surmounted in the use of the microscope are (1) obtaining a platform for the microscope which is stabilized with respect to inertial space down to about 2 cps, and (2) obtaining a reference point on the shaker platform which is small enough in diameter (0.0001″), yet easily located and easily resolvable when in rapid motion through the travel limits of other moving illuminated areas.

Condition (1) eliminates mounting the microscope on a floor stand or the shaker frame. As the shaker frame is normally mounted on a 500-1500-lb concrete block suspended on springs, it is usually convenient to mount the microscope on a superstructure secured to the concrete block. This permits observation of frequencies down to about 20 cps because the spring suspension will normally have a resonance of one-tenth this frequency (2 cps or less).

The second condition, that of obtaining a suitable reference point for observation, can be met by mounting a small piece of #80 emery cloth on the work platform of the shaker and using side illumination on the emery-cloth particles (Figs. 3 and 4). Each of the pin points of light observed under the microscope will appear to draw fine bright lines (0.0001″ wide or less) in the configurations of Fig. 5 when the work platform is in motion.

Under strong illumination, little can be seen due to glare, but when the illumination is weakened and directed properly, it becomes possible to select one or more fine bright lines against a dark background. A typical set-up is shown in Fig. 4.

Making Measurements

For observing double amplitudes of 0.020″ or greater, a 40-power microscope is used; a 400-power microscope is required to cover the range of double amplitudes between 0.002″ and 0.020″. For amplitudes less than 0.002″ an electronic method of observation (to be covered in a subsequent report) has been employed.

A suitable 40-power microscope can be made up of the following Bausch & Lomb parts: (1) #31-29-03-01 microscope tube with adjustable draw tube, (2) #31-15-53-20 x widefield eyepiece with #31-16-02 recticle, and (3) #31-10-05-01 2x objective.

The reticle contained in the eyepiece is used to measure the amplitude of vibration by noting the length of the bright line along the reticle scale. The 31-16-02 reticle scale (when 40-power magnification is used) has a length of 0.200″ and has 100 linear divisions, numbered in sets of ten from 0-10. The scale can be read accurately to ± one-quarter division, or ± 0.0005″. However, it must be remembered in making measurements to use the proper multiplying factor (0.020) to convert scale numbers to length in inches.

As the reticle scale has a calibration that depends on the position of the eyepiece in the draw tube, it is necessary to fix the eyepiece in the draw tube at the point of proper calibration. This is done by focusing the microscope on a stage micrometer (a precision-ruled glass slide) and adjusting the eyepiece position for exact coincidence between the images of the ruled lines of the reticle and the ruled lines of the stage micrometer. Bausch & Lomb #31-16-18 stage micrometer is a suitable type. During calibration, the image of the stage micrometer is kept in focus by use of the draw-tube rack and pinion.

The above procedure amounts to slightly altering the magnification achieved by the microscope objective in order to obtain the exact magnification required at the image plane of the reticle. Normally, the calibrated position of the eyepiece is about 3/16″ removed from the point where the eyepiece seats against the draw tube, so that a spacer ring can be constructed for the eyepiece to seat against. It is recommended that the spacer ring be stamped "For use with 31-10-05-01 2x objective" when there is the possibility that another objective may be substituted. Fig. 4 shows the spacer ring installed on the 40-power microscope described.

The microscope can be converted to approximately 320 power by substituting the Bausch & Lomb 42-33-07-93 trivert objective in place of the 31-10-05-01. The same stage micrometer and procedure as before is used to calibrate the reticle, but the reticle scale will now be interpreted as having a length of 0.025″. The same spacer ring might be used when either of the above objectives is installed because both are constructed so that their images fall nearly in the same plane at the proper magnification. At this magnification, crocus cloth should be substituted for the #80 emery cloth to obtain better contrast and smaller particles.

Waveform

Fig. 5 shows six typical patterns observed with the microscope at right angles to the plane of the shaker flexures. Pattern A shows straight-line motion in line with the vertical shaker axis. As the line is drawn by a moving dot, it is apparent that the true amplitude of motion will be less than the line length by exactly the diameter of the moving dot. Thus, the amplitude of motion is equal to line length with line width subtracted. This is a fixed correction to be applied to all such measurements. The line width can be measured by rotating the eyepiece 90° so that the reticle is transverse to the line.

Patterns B through F show sidesway which arises from a combination of mechanical resonances and, in some cases, from poor centering of the work load above the thrust axis of the platform. Patterns E and F show the frequency doubling which is a characteristic of any mechanical system where side stress is repeated in the same direction at both the upper and lower limits of travel.

Elimination of the observed sidesway has been discussed in the literature[2], showing how sidesway introduces calibration errors and what can be done toward its elimination.

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Testing with a G-ACCELERATOR

The Edwards Air Force Base installation of a G-Accelerator provides means for subjecting equipments of up to 300 pounds to acceleration forces of up to 60 g's. Design considerations, balancing, instrumentation, and uses are presented.

RALPH BROWN
Genisco, Inc.

IN aircraft and missile development it is becoming increasingly advantageous to subject instrumentation, equipment and components to operational testing under simulated flight conditions prior to acceptance and installation. One of the most important flight conditions centers around accelerated g loading. Outside of actual flight, only two methods are feasible for these tests —one is by straight-line acceleration on a powered sled held captive on a track, and the other by rotary motion where centrifugal forces, angular acceleration, or both are utilized. The rocket-sled approach is practical only for large bases where miles of unobstructed travel are available. A combination of a vehicle on a rotary track is possible, but when using a powered vehicle it is difficult to hold a condition of steady-state acceleration free of extraneous vibration, as required in the calibration of force-measuring instrumentation. Also, the duration of steady-state acceleration conditions may be limited seriously. A test platform supported from and rotated by a central shaft whose speed can be infinitely varied and accurately controlled becomes the logical approach.

Genisco has supplied a total of about seventy-five such centrifuge machines in four- and eight-foot-diameter

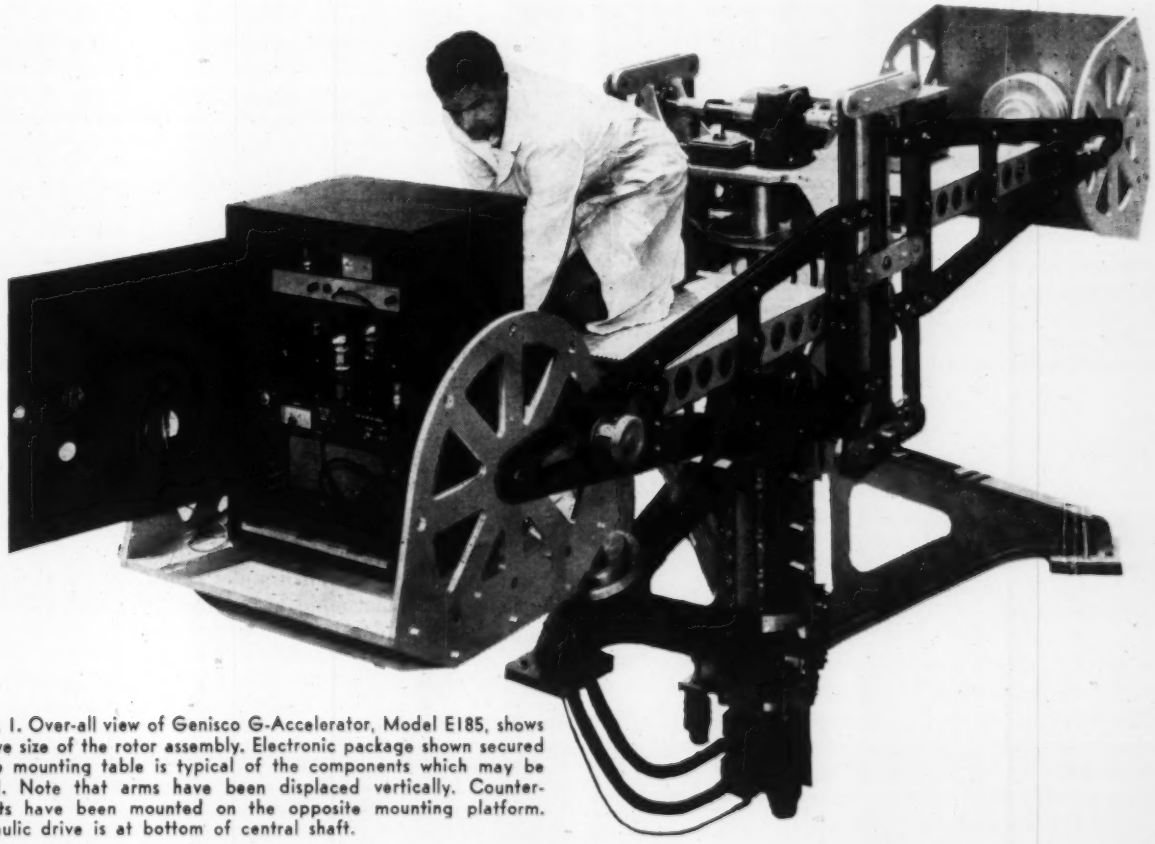

Fig. 1. Over-all view of Genisco G-Accelerator, Model E185, shows relative size of the rotor assembly. Electronic package shown secured to the mounting table is typical of the components which may be tested. Note that arms have been displaced vertically. Counterweights have been mounted on the opposite mounting platform. Hydraulic drive is at bottom of central shaft.

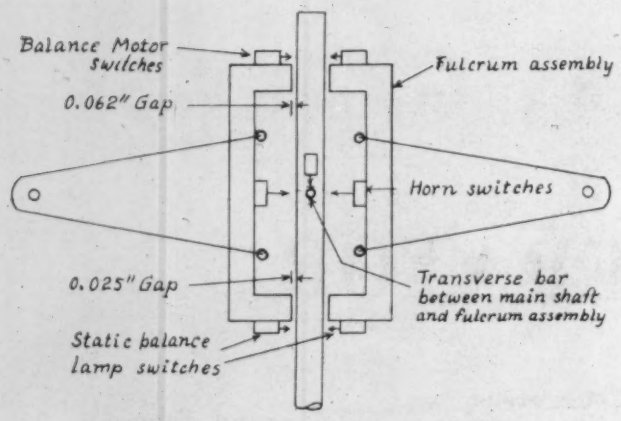

Fig. 2. Static and dynamic balance mechanism.

sizes to customers in the United States, Canada, Europe, and Japan. The machine described is the largest yet attempted by Genisco and is installed in a sixteen-foot-diameter pit at Edwards Air Force Base, Edwards, California. It is designated as the "Model E" and is capable of subjecting a 30-inch cube weighing up to 300 lbs (or two such packages if counterweights are not used) to acceleration forces up to 60 g's. Static balance is accomplished manually. Dynamic balance is fully automatic. Numerous electrical interlocks and safety measures make it reasonably foolproof and virtually safe for operating personnel.

Design Considerations

In designing larger centrifugal testing machines for carrying big payloads, several problems arise which can be neglected in smaller machines. These factors arise because several forces increase by the cube whereas the strength of materials increase by the square, and dynamic unbalance forces cannot be absorbed conveniently by the support structure. Therefore, a means of achieving dynamic balance is more desirable than beefing up structural components to an unwieldy degree. Furthermore, in order to relieve operator responsibility, it is advisable to provide an unbalance sensing system so that the machine can seek automatically a condition of tolerable unbalance, and will shut down of its own accord if it cannot sufficiently compensate for such unbalance.

Another design consideration is selection of an optimum radius of gyration. A minimized radius is most economical as to rotor strength and required horsepower. However, centrifugal force varies directly with radius. For large test packages it is necessary to make the radius of gyration large in order to minimize the "g-gradient" across the test object. For example, a 2-foot test object whose inner edge falls at a two-foot radius while the outer edge is at a four-foot radius will have a g-gradient of $\pm$ 33% from the centrifugal forces at its midpoint, and the g force at the outer edge will be twice that at the inner edge. On the other hand, a large radius imposes other problems.

Balance Accommodation

Dynamic unbalance in a double-ended rotor occurs when the composite center of gravity of each end lies in a different plane. Dynamic unbalance forces appear as a couple resulting in a bending moment in the main supporting shaft.

After consideration of the several methods that could be used for balancing, the system finally chosen requires manual static balancing, and compensates for dynamic unbalance by relative vertical displacement of the two symmetrical halves of the rotor assembly. The two arm assemblies are carried on aircraft-type track roller bearings which ride on hardened-steel vertical tracks. Vertical travel is accomplished by an endless chain drive on each side driven from a common source (a ¼-hp electric motor and a reduction gear box mounted close to the center of rotation in order to minimize centrifugal forces to which the motor is subjected).

Unbalance Sensing

The unbalance sensing system is contained in the central "fulcrum assembly" which is pivotally mounted on and rotationally driven by a transverse stainless-steel shaft passing through the vertical main shaft (Fig. 2). The fulcrum assembly is free to pivot a slight amount without deflecting the transverse shaft in order to actuate the first pair of Microswitches (at the lower level of the fulcrum assembly) which indicate static unbalance. A green lamp shows at the light end and a red one at the heavy end. A mechanical stop is encountered immediately after the first Microswitch is actuated; if a sufficiently large moment is present, the transverse shaft deflects enough to cause one of the pair of Microswitches on the top level to actuate, which energizes the balance motor in a given direction. Thus, if one platform is about 50 lbs heavier than the other, the "heavy" arm sinks to a limit switch and the main drive motor becomes inoperative. If the two arms are statically equal, there is no tendency for the balance motor to drive in either direction. When rotation reaches a level where the couple generated by dynamic unbalance is sufficiently large to actuate the balance motor, it will drive in the correct direction until the two forces resolve into a single plane and the couple disappears. A second mechanical stop prevents the fulcrum assembly from pivoting an amount more than that required to actuate the switches. In actual practice, the balance motor begins to actuate at an equivalent speed of about 3 g's and completes its compensation within 20 seconds maximum. Were the machine unable to compensate within the limited travel, a limit switch is actuated and the machine is shut down; however, the travel is sufficient to allow complete compensation if the center of gravity of the test object or objects falls within the prescribed 30-inch cube.

Overload Warning

The yieldable feature of the transverse shaft is put to use also in the vertical plane to sense initial static overloading, and insufficient static counterbalance under dynamic conditions. In the first case, if more than 600 lbs of payload (including counterbalance) is imposed on the rotor assembly, the transverse shaft deflects downward enough to actuate a single Microswitch mounted on the middle level of the fulcrum assembly, which sounds a warning horn and renders the machine inoperative.

In the second case, if one platform is pronouncedly heavier than the other, the fulcrum assembly moves toward the heavy platform under centrifugal force so as to engage both mechanical stops on the same side of the main shaft, which is enough movement to actuate one of a third pair of Microswitches connected to the warning horns (Fig. 2). In this case, however, the machine does not shut down; the balance motor actuates to create a restoring couple moment, one leg of which resolves the unbalance into the upper main bearing of the main shaft where it can be safely accommodated without imposing a bending moment on the main shaft.

Power Requirements

Oddly enough, aerodynamic drag is the main determinant for power requirements. Friction is almost entirely air drag. If this drag is figured purely from equivalent flat plate area formulas, power requirements amount to about 40 hp. If, however, the machine is enclosed so that the contained parcel of air is allowed to rotate with the moving parts, the power requirement drops considerably. In addition, if the enclosure is made circular, concentric, and free from irregularities so that it is aerodynamically clean, drag decreases to that equivalent to surface conditions only, and streamlining of the rotor becomes almost superfluous. By taking full advantage of aerodynamic conditions, it proved feasible to drive the Edwards machine with a 7½-hp motor. Only 15 seconds are required to achieve from 0 to 30-g acceleration; only 45 seconds for 0 to 60-g acceleration.

Several kinds of variable-speed power sources are available to drive centrifuge equipment. The best from the standpoint of initial cost, long life, low maintenance and smoothness of rotation without oscillation, seems to be hydraulic. In the Model E centrifuge, the hydraulic motor is coupled directly to the lower end of the main shaft and is so small as to appear ridiculous for a large machine.

The hydraulic configuration chosen consists of a variable-displacement pump driven at 1750 rpm by an electric motor, and a hydraulic motor having ten times the volumetric displacement per revolution as the maximum displacement of the pump. This combination accomplishes a ten-to-one speed reduction without the use of gear boxes, thus eliminating backlash, gear noise, and lubrication problems. Speed is governed by a handwheel on the console which controls the volumetric displacement of the pump from zero to maximum. A relief valve prevents system overload. Hydraulic braking is accomplished by venting the pressure line and constricting the return line through a relief valve when the hydraulic motor is acting as a pump being driven by the inertia of the rotor assembly. Additional braking is available by hydraulically reversing the system through a four-way solenoid valve; inclusion of the reversing valve permits driving the machine in either direction.

Instrumentation

A continuously indicating *tachometer system* is a problem in rotating equipment having a wide speed range. Rough speed indication (within 1%) is accomplished by an aircraft-type tachometer-generator and indicator. Precise speed is indicated on a selsyn-driven stroboscopic disc on the console panel, which is illuminated by a line-frequency strobe lamp and which indicates speed to the accuracy of the line frequency in increments of 5 rpm. Both the tachometer generator and the selsyn transmitter are positively driven from the main shaft by a Gilmer cogged timing belt at ratios best suited to each system. If line frequency is not accurate to within 0.1 percent, a precision frequency for the strobe lamp can be supplied by a precision tuning fork.

Thirty-two sliprings are built into the tripod support assembly of the main shaft, eight of which are used for balance motor, interlock, and warning horn systems. The rest are divided between power and shielded instrumentation leads. No optical system is provided because of the long optical path, but a small industrial television camera can be installed on the inboard edge of one of the rotor arm assemblies where centrifugal forces are negligible.

To assist the operator in reading directly the magnitude of g-acceleration experienced by objects under test, a drum scale is mounted on the main console of the machine. This scale is calibrated in terms of revolutions per minute and radii from center of rotation so that an operator can take a large number of discreet test points, corresponding with predetermined values of g-acceleration.

Fig. 3. Rotor assembly of the G-Accelerator is controlled from this remotely located control panel. The selsyn-driven strobe disc is located in the center of the panel. The chrome handwheel in the upper right corner of the panel controls the speed of the boom assembly.

Uses

Smaller accelerators are used in the laboratory for testing relays, electron tubes, capacitors, sub-assemblies, motors, valves and other equipment which must function in an acceleration environment. In the laboratory, smaller accelerators are used for calibrating accelerometers.

Accelerators are used also on production lines to test samples or all units designed to go into missiles or aircraft.

Larger accelerators are used primarily in the laboratory for testing electronic packages and components, guidance systems, fire control systems, gyro packages, servo-motors or systems, human beings, guns, turbines, motors, missiles, or similar objects found in the field of rocketry and flight.

A recent use is in connection with whole gyroscope packages; under such circumstances they provide both a precisely calibrated rate of turn as well as precisely known acceleration forces on the objects being tested. Thus guidance or control systems can be tested in the laboratory under simulated flight conditions.

Much time and effort can be lost if flight-test instrumentation fails. If tests can be made on the ground by one or two technicians who are not held to a tight coordination schedule, a centrifuge machine can pay for itself in a short time.

A large machine can be used to test and calibrate small equipment, whereas a small machine is limited in its capacity. In addition, a large radius of gyration is a distinct advantage in that the g gradient across an object is less. For production testing, a large number of small objects can be tested simultaneously; the large machine may be more efficient than a small one.

There are two classes of digital computers—general-purpose and special-purpose. The digital differential analyzer, or DDA, is a special-purpose computer designed especially for the solution of differential equations. Features, operation, and application of the G-15 General-purpose and the D-12 DDA computers are presented.

Fig. 1. G-15 General-purpose Computer is a stored-program-controlled binary computer featuring magnetic-drum memory of 2160 words, and average access time of 14.5 milliseconds.

DIGITAL COMPUTERS—

THERE ARE two types of digital computers (both of which are manufactured by the Bendix Computer Division of Bendix Aviation Corporation). One is the *general-purpose computer*, which adds, subtracts, multiplies, and divides at a high rate of speed as controlled by a program. The other is a special-purpose fixed-program computer designed especially for the solution of differential equations, and called the *digital differential analyzer, or DDA*.

Features of General-purpose Computers

The general-purpose computer of Bendix is known as the Model G-15A (Fig. 1). It is of the stored-program type, and is particularly efficient in the use of repetitive-type programs and subroutines wherein the mechanics of solution remain the same, but the input data varies from one solution to the next. This type of problem is found commonly in control situations.

The *program* for the computer defines each step that the computer must take in order to reach the solution. *Subroutines* are usually short programs used as portions of the over-all program.

General-purpose computers are useful for the study of systems described mathematically. Such systems can be studied as a whole—or each of its parts may be studied. Once the program for a system has been prepared and entered into the machine, the variable conditions under which the system must operate may be entered and the computer instructed to solve for the desired performance data. This is a powerful tool in the establishment of control systems, their performance and limitations.

The general-purpose computer could be used also as an element of a control system—accepting input data, performing necessary mathematical operations and decisions, and controlling output devices through accessories. In this sense the computer would be the monitor and arbiter of the controlled system.

Fields of application for such a general-purpose computer are many and varied. Computers have been used, for example, in the reduction of seismographic data, the correlation of rainfall data, in an analysis to obtain available power from a hydroelectric dam, in crystallographic studies, and in the field of linear programming. Other applications include the design of gas transmission and distribution systems, the design of special-purpose tools, and the preparation of programs for numerically-controlled machine tools.

Features of the Digital Differential Analyzer

The Bendix DDA is known as the Model D-12 (Fig. 2). It has a fixed program and is designed primarily for the solution of problems involving differential equations of any order, linear and nonlinear, and of simultaneous sets thereof.

Many control systems can be described by differential equations; the DDA would offer advantages over a general-purpose computer for the study of such systems. Like the general-purpose computer it could be used also to operate directly in control systems.

Fields of application include optics, aerodynamics, chemistry, and analytical mechanics. The DDA is particularly effective for the solution of complex engineering

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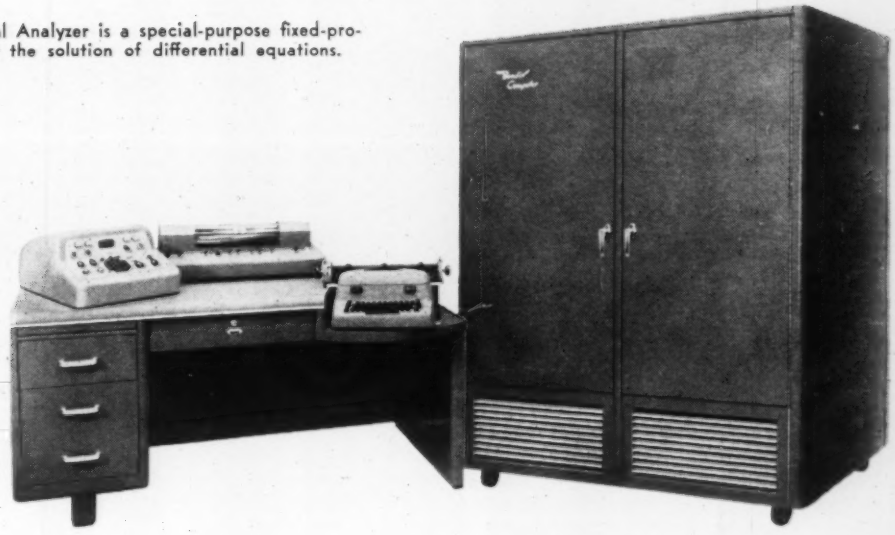
Presented at the Computer Clinic, First Automation Exposition, New York, N. Y., Nov. 30-Dec. 2, 1954.

Fig. 2. Model D-12 Digital Differential Analyzer is a special-purpose fixed-program computer designed especially for the solution of differential equations.



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General-purpose and DDA

problems associated with physical systems. It may be used in preference to or in association with the general-purpose computer to permit easier programming. The DDA will be described after the description of the general-purpose computer.

G-15 GENERAL-PURPOSE COMPUTER

The basic functions of a general-purpose computer are multiplication, division, addition and subtraction. Numbers are stored in the G-15 in absolute value and sign as words of either 29 or 58 binary digits. Operation is binary; numbers are operated on serially—that is, the numbers advance serially in a stream and are operated on individually. All specifications are listed in Table 1 (on the following page).

The last item in this table pertains to the Model G-15D, which incorporates a Digital Differential Analyzer having 54 integrators and 54 constant-multipliers. (The DDA will be described later; it may be obtained and used either separately or as a part of the G-15D General-purpose Computer.)

G-15 Memory

As shown in the table, the memory is a magnetic drum rotating at 1800 rpm. An individual number or sequence of numbers can be stored in the memory, or transferred from one position to another, by means of a single command.

The memory permits the storage of 20 lines of 108 words, or 2160 words. Average access time is 14.5 milliseconds; 4 lines of 4 words (16 words) provide for fast access of 0.54 millisecond. The memory also contains three 2-word and one 1-word arithmetic registers which hold words taken from the main drum for arithmetic operations as needed.

G-15 Commands

The commands provide for all logical operations—addition, subtraction, multiplication, division, branching, etc. Flexibility and high-speed operation result from an improved 2-address command because each command specifies not only the operation to be performed but also the location of the next command.

The command specifies not only the operation and location, but also the precision. For example, multiplication at *single precision* results in a product of 56 binary places; multiplication at *double precision* results in a product with 114 binary places. Where less precision is required, multiplication can be terminated at any appropriate number of places, with corresponding saving in time.

A *normalize command* automatically shifts a number in one of the arithmetic registers until its absolute value is between 0.5 and 1.0. This makes possible fast floating-point subroutines. As this shifting takes place, the number of binary places shifted is automatically tallied in another register; this tally is used as the exponent in floating-point operations.

G-15 Operation Times

As mentioned, the basic operations are multiplication, division, and addition. The time for each operation depends on the precision desired (the number of binary places requested). For example, multiplication or division for maximum single precision (to 56 places) requires 16.7 milliseconds; 33.1 milliseconds for 114-place precision. Addition times are 0.54 millisecond for 28-place

single precision; 0.81 millisecond for 57-place double precision.

G-15 Input and Output Devices

The standard input/output facilities are an electric typewriter (10 characters/sec) and punched paper tape (a 200-character-per-second photoelectric paper-tape reader is included). Optional facilities include magnetic-tape units; as many as four tape units can be used effectively with one G-15. Facilities may provide also for use of the G-15 in reading or punching punched-cards, or for actuation of a line printer. A graph plotter also is available.

Table 1.—
Specifications of G-15 General-purpose Computer

Type	General purpose, stored program, serial, binary
Memory	Magnetic drum—1800 rpm 20 lines of 108 words (2160 words) Average access time—14.5 msec. 4 lines of 4 words (16 words) Average access time—0.54 msec. 3 two-word and 1 one-word arithmetic registers
Commands	Special type of two address commands for transferring words Addition, subtraction, multiplication and division at single or double precision Shifting and normalization for convenient floating point operation Conditional transfer of control
Operation Times (Minimum including reading of command)	Multiplication— 16.7 msec. for single precision 33.1 msec. for double precision Division— 16.7 msec. for single precision 33.1 msec. for double precision Addition— 0.54 msec. for single precision 0.81 msec. for double precision
Numbers	Stored as absolute value and sign Either 29 or 58 binary digits
Input/ Output	Input and output decimal or sexadecimal Standard equipment— Electric typewriter— 10 characters/second Mechanical tape punch— 15 characters/second Photo-electric punched tape reader —200 characters/second Accessory equipment— Magnetic tape units Coupling unit to punched card reader, card punch or line printer Graph plotter
Physical Features	Size—computer cabinet: (32" wide by 27" deep by 60" high) Cooling: forced air Power input: 230 volts, 60 cycles, single phase, approximately 3 kva
Differential Analyzer	54 integrators 54 constant multipliers 34 iterations per second

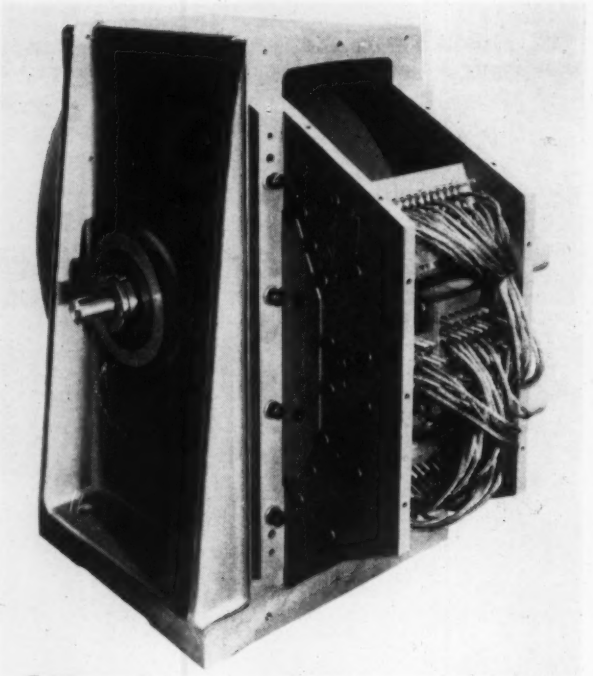


Fig. 3. G-15 memory has magnetic drum rotating at 1800 rpm, permits storage of 2160 words. Three 2-word and one 1-word arithmetic registers hold words taken from the main drum for arithmetic operations, as needed.

G-15 Operation

Computer operation is controlled entirely from the electric typewriter. This includes starting and stopping, control of auxiliary equipment, basic command, or commanding the contents of the accumulator to be typed out for examination. The typewriter can be located at a distance from the computer.

When a computer has been programmed and put into operation, the program may be interrupted at desired points for examination of program or computer operation. These points are called *break points*. They are used primarily when checking out a program and are usually ignored after the program is "debugged." Break points may be inserted or removed at will; ignoring of the break points is made possible by a switch on the typewriter.

The *mode of operation* of the computer (selected by a switch on the typewriter) may be either (1) proceed, one command at a time, from break point to break point, or (2) proceed, one command at a time, to any desired programmed halt.

Subroutines may be entered via the typewriter to simplify programming. Users maintain subroutine libraries of paper (or magnetic) tape.

Whenever computation is halted, the MARK PLACE key on the typewriter is actuated. This automatically stores, at a special address in the memory, the address of the next command from the command register and the information contained in the accumulator of the arithmetic section. (This accumulator contains results up to time of stopping if so programmed.) It then is possible to use checking subroutines or to insert commands directly from

Loc.	i/d	T	Tn	ch	S	D	s/d	Notes
000	+	002	003	0	23	31	+	CLEAR 2-WD REG. (1)
004	+	006	006	0	28	24	+	θ = (A.0) → MQ (2)
006	+	008	009	1	00	25	+	$10^6.2^{-24}$ = (7) → ID (3)
009	+	008	018	0	24	31	+	MULTIPLY (4)
018	+	020	021	1	00	25	+	$10^5.2^{-24}$ = (19) → ID (3)
021	+	008	030	0	24	31	+	MULTIPLY (4)
030	+	032	033	1	00	25	+	$10^4.2^{-24}$ = (31) → ID (3)
033	+	008	042	0	24	31	+	MULTIPLY (4)
042	+	044	045	1	00	25	+	$10^3.2^{-24}$ = (43) → ID (3)

Fig. 4. Sample program for a G-15A Computer. Part of program indicated gives the first few steps of a typical subroutine for the reduction of a decimal number to a binary number which can be operated on by the computer. Loc. is location of command to be obeyed; i/d defines whether it is an immediate or deferred command; T specifies the time of operation of a deferred command, or when operation is to stop if an immediate command; Tn is location of next command; ch is the transfer characteristic, or the operation to be performed on the number or numbers involved; S is the Source; D is the destination; s/d determines whether the command is single or double precision.

the typewriter keyboard. Actuation of the RETURN TO MARKED PLACE key restores the accumulator and the command register to their condition prior to the MARK PLACE operation.

Typical Program

Fig. 4 shows part of a subroutine for the reduction of a decimal number to a binary number which can be operated on by the computer (reducing an angle θ, expressed decimally in radians, into sin θ in binary form). The column headings are as follows:

Loc. is the location of the command to be obeyed.

i/d defines whether it is an immediate or deferred command.

T specifies the time of operation (for a deferred command), or when the operation is to stop (if an immediate command).

Tn is location of next command.

ch is the transfer characteristic, or the operation to be performed on the number or numbers involved.

S is the source.

D is the destination.

s/d determines whether the command is single or double precision.

The notes tell the significance of each step. For example, the first step means clear register; the second says that the value of θ is inserted into the accumulator (AR) and transferred to the MQ register; step three is the conversion from decimal to binary form; etc.

DIGITAL DIFFERENTIAL ANALYZER

A digital differential analyzer is designed specifically for the solution of differential equations. The basic function is the numerical integration of any variable (x) with respect to any variable (y), linear or nonlinear—that is, $z = \int y dx$. The third variable (z) may be plotted automatically as integration proceeds.

Integration is essentially an addition operation—that is, the area under the curve of z is added to obtain the result. The integrators of the computer can be coded to perform addition, multiplication, division, comparison, limiting decision, and servo operation.

Specifications of the DDA are shown in Table 2.

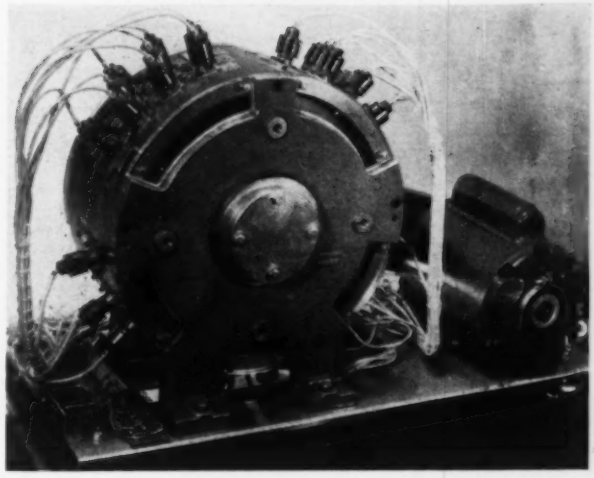


Fig. 5. D-12 memory has 14 tracks, rotates at 4000 rpm.

Operation

Operation of the Bendix DDA is entirely decimal, including coding, scaling, filling, and output. Programs are prepared using standard decimal numbers. Results of the computation are recorded as columns of tabular data printed by the electric typewriter; negative and positive decimal numbers are tabulated. The variables selected for tabulation may be recorded graphically or in tables as a function of any variable generated by the machine.

The basic units are the computer cabinet and the control console (Fig. 2). The computer cabinet contains the

Table 2.—Specifications of D-12 DDA

MATHEMATICAL

1. Method of fill: automatic program or manual
2. Numbering system: decimal
3. Capacity: 60 integrators
4. Precision: 7 decimal digits
5. Modes of integration: rectangular, interpolative or extrapolative
6. Speed: 100 iterations per second, 1-60 integrators
   200 iterations per second, 1-30 integrators
7. Input channels: 8 incremental channels
8. Output channels: 12 incremental channels

POWER

1. Power input: 208/230 volts ±10%, 60 cps single phase, 6 KVA

MECHANICAL

1. Computer cabinet: 27" deep by 60" wide by 72" high
2. Control console: 32" deep by 60" wide by 37" high
3. Cooling: forced air circulation
4. Gross weight: 2000 lbs.

EQUIPMENT

1. Computer cabinet containing:
   (a) Arithmetic section
   (b) Address section
   (c) Memory unit
   (d) Power supply
2. Control console containing:
   (a) Punched tape mechanism
   (b) Electric typewriter
   (c) Graph plotter
   (d) Control center
3. Interconnecting cable (20 ft.)
4. Operations and Maintenance Manual (2)
5. Spare plug-in packages (36)

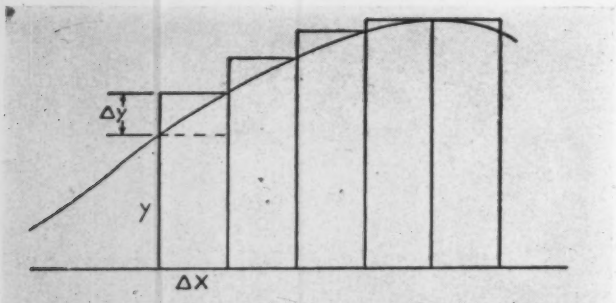


Fig. 6. Rectangular, or Euler, integration approximates the area under the curve by adding up the series of rectangles.

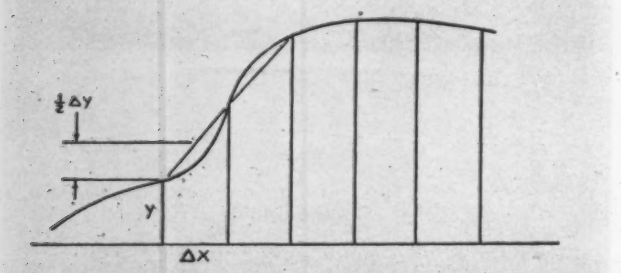
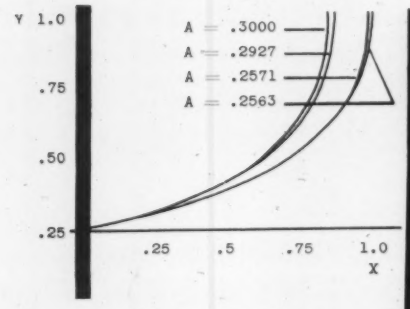


Fig. 7. Trapezoidal integration approximates the area under the curve by adding the series of trapezoids, producing a result more closely equal to the integral (area under the curve) than rectangular integration. Interpolative integration uses the fundamental area $(Y + \frac{1}{2}\Delta Y)\Delta X$.

$$y(x) = 0.25 + \int_0^x \frac{Ay(t)\ [1 + 0.14y(t)]\ [1 + 0.02752y(t)]\ dt}{[1 - y(t)]\ [1 - At]}$$



$x.10^3$	$y.10^3$	$A.10^4$
Initial conditions:		
0000	0250	3000
0854	1000	2927
0875	1000	2865
0894	1000	2812
0911	1000	2767
0926	1000	2730
0938	1000	2699
0993	1000	2573
0995	1000	2571
0996	1000	2569
0997	1000	2567
0998	1000	2566
0998	1000	2565
0998	1000	2564
0999	1000	2563
0999	1000	2563

Fig. 8. Typical use of DDA in solving an integral equation. Value of A is desired such that $y = 1$ at $x = 1$. Tabulated values of x at $y = 1$ for various values of A were typed automatically, as shown. Curves of x vs y for various values of A also were produced.

(a) arithmetic unit, (b) address section, (c) memory unit, and (d) power supply. The arithmetic section consists of unitized flip-flops, inverters, buffers, amplifiers, gates, and other standard computer elements. The memory drum (Fig. 5) has 14 tracks, is approximately 11 inches in diameter, and rotates at 4000 rpm.

All operation of the computer is controlled from the monitor-control panel, which contains switches for starting, stopping, insertion of problem, read-out, etc. An oscilloscope (on the control console) is provided for examination of information in any integrator.

The computer is filled automatically by decimal information recorded on punched-paper tape prepared by the electric typewriter. Automatic tape filling permits rapid entry of problems and insertion of functions and tabulated data, during computation.

An example of typical input copy for a problem is shown in Table 3. The first 2 digits identify the integrator (of which there are 60 available). The next group is the initial conditions of the integrand; the remaining digits specify control functions and addresses. Each integrator can be filled in less than 5 seconds.

Table 3.—Typical Input Copy For DDA

16	−196	150201	15	03	13	14	21	47
17	+035306	100001	58	04	16			
18	+14673	010510	59	16	18	36		
19	−00000000	130000						

Modes of Integration

The conventional digital differential analyzer consists of a number of fixed-program digital integrators serially performing simple quadratures—that is, multiplying the two sides of a rectangle to obtain the area within the rectangle. The equation for this fixed-program operation has commonly been $z = \int y\,dx$ (or, more accurately, $\Delta z = y\Delta x$). As shown in Fig. 6, this is rectangular, or Euler, integration. The area under the curve is approximated by summing the series of rectangles, each of which has the area $y\Delta x$.

The error between the actual area and the sum of the rectangles can be reduced by use of *trapezoidal integration*, shown in Fig. 7. Here the area is that within the trapezoids, which is a closer approximation to the actual areas. The Bendix DDA uses a technique called the trapezoidal rule, wherein the fundamental area of integration is $(Y + \frac{1}{2}\Delta Y)\Delta X$, as shown in Fig. 7. This is known also as *interpolative integration*. The DDA can use either rectangular, interpolative or extrapolative mode of integration, as desired. (Extrapolative integration uses a fundamental area $(Y + 3/2 \cdot \Delta Y)\Delta X$.

Ternary Transfer

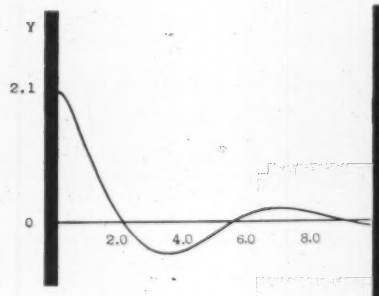
An even more serious error than that occasioned by integration error is that produced by round-off, particularly when binary transfer is used as the intercommunication method within the computer. For example, if each integrator output (which is the input to the next integrator) must be either plus or minus one, the error will be a full unit if the integrator output is zero.

In the ternary scheme of integrator intercommunication (used in the Bendix DDA) the output of an integrator may be −1, 0, or +1. The advantages of ternary transfer are (1) reduction of error and (2) speed is doubled because the significance of each unit is always apparent.

Iteration

Each integrator is an adder which adds increments of areas. The process is as follows: Information required for each integrator is placed on the memory drum. Information on the drum is read from the drum into the integrator and summing circuits, and the result is placed back on the drum. As there are 60 integrators, there are 60 positions on the drum for information. Each position is processed once per drum revolution; each processing is called an *iteration*. The speed of operation is 100 iterations per second when the 60 integrators are used; the

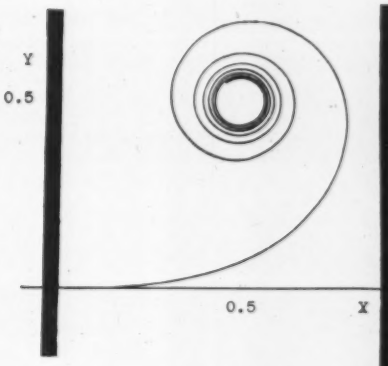
$$\frac{d^2y}{dx2} = -0.5\left(\frac{dy}{dx}\left|\frac{dy}{dx}\right|\right) - 0.4\frac{dy}{dx} - y$$



x.10²	y*.10²	y'.10²	y.10²
00000	-210	0000	2100
00200	-182	-0396	2059
00400	-140	-0720	1946
00600	-095	-0954	1778
00800	-053	-1100	1343
01000	-019	-1170	1343
01200	006	-1182	1107
01400	025	-1150	0873
01600	037	-1087	0649
*****	***	*****	*****
*****	***	*****	*****
11800	-002	0069	-0015
12000	-003	0064	-0001
12200	-003	0058	0011
12400	-004	0051	0022
12600	-005	0041	0031
12800	-005	0031	0038
13000	-005	0021	0044
13200	-005	0010	0047
13400	-005	0000	0048
13600	-005	-0010	0047
13800	-005	-0018	0044
14000	-003	-0024	0039

Fig. 9. Another typical use of the DDA is solution of nonlinear differential equations, such as shown. Top row of tabulated data are the initial conditions for d^2y/dx^2, dy/dx, and x. Value of x over 14 units of y was solved and tabulated in 6 minutes of computer running time. Curve was drawn automatically by plotter.

$$x = \int_0^t \cos\frac{\pi u^2}{2}\,du \qquad y = \int_0^t \sin\frac{\pi u^2}{2}\,du$$



t.10⁴	x.10⁵	y.10⁵
00000	00000	00000
01000	10000	00051
02000	19993	00417
03000	29941	01411
04000	39749	03338
05000	49235	06470
06000	58111	11050
07000	65967	17208
08000	72287	24928
09000	76485	33971
10000	77994	43819
*****	***	***
*****	***	***
41000	57375	47575
42000	54177	56316
43000	44949	55396
44000	43838	46223
45000	52607	43423
46000	56729	51615
47000	49148	56711
48000	43385	49671
49000	50021	43503
50000	56368	49615

Fig. 10. Evaluation of integrals is common problem for DDA solution. Shown is the solution of Fresnel Integrals, which occur in physical optics. Tabulated data was printed out automatically, as was the curve of y vs x, which is a Cornu Spiral. Solution required 11 integrators.

speed is 200 iterations per second when 30 or fewer integrators are used.

To provide ternary inputs at a rate of 100 iterations per second would be costly. Rather than reduce machine speed, a *second-order interpolation* scheme is used. A slow tape reader (of the Teletype variety) reads second differences into an integrator chain with the desired output rate. During computation over one interpolation interval, the value in the next interval is read into the initial-condition channel from which, at a pre-arranged signal, it is read into the computation channels. This eliminates the need for stopping computation, and is especially useful when a reversal of the independent variable causes a reversal in tape direction.

Other Operational Features

Re-entry. Provision is made also for reading the second derivatives of variables onto a tape in a form that makes possible their re-entry into computation. This allows functions generated in one problem to be used in another, effectively increasing the size of the computer.

Time Reversal. A switch located on the monitor-control panel permits the stopping or time reversal of the independent variable. This permits re-examination of any problem region.

Automatic Parameter Variation. The initial conditions can be varied in accordance with the results. When desired values are obtained, the generated parameters can be automatically inserted, and the new problem solved using the new set of initial conditions.

Initial-Condition Reset. The initial conditions of a problem are retained in the memory throughout computation. They may be reset at any time by at switch. New parameters can be entered manually so that repetitive problems involving minor modifications in initial conditions can be solved efficiently.

Output Multipliers. The digital output rate of any integrator can be multiplied by a factor of 2 or 5 by a single program digit code. This simplifies scaling and saves computer time.

Expanding Capacity. Computers can be coupled by availability of 8 input and 8 output channels on each computer. These permit intercoupling of computers, insertion of additional information, and use of additional graph plotters.

Error Detection. Computation stops immediately on (1) existence of prohibitive codes, (2) double output from a single integrator, (3) overflow of an integrator (except when coded for servo operation). Lights on the monitor-control panel indicate such errors. A push switch provides for clearing of such stoppages.

Tape Libraries. Programs on tape permit establishment of tape libraries. Computed and empirical functions can be placed on the tape and stored. Entire contents of the arithmetic and address channels can be punched on the tape for continuation of computation at a later time.

Typical Problems

In Fig. 8, the integral equation to be solved is given. Specifically, it is desired to know the value of A such that $y = 1$ at $x = 1$. The solution shown required use of 17 integrators.

It was known that A was approximately 0.3; this was used as the initial condition. Other initial conditions were that $x = 0$ at $y = 0.25$. Tabulated values of x (at $y = 1$) for various values of A were typed automatically, as shown at bottom right of Fig. 8.

y was maintained at a fixed value of 1. As each value of A was computed for a change in x, it was tabulated. After 6 tabulations, a larger change in x was ordered to obtain the solution more rapidly, as shown. Each computed and tabulated value is automatically reset into the computer to obtain the next computed value.

Note that as x approaches 1, an infinite discontinuity exists at the point $x = 1$ (which is the desired result). The final value for A at the solution point ($x = 1$; $y = 1$) is approximately 0.2563.

The associated graph plotter can plot the curve of y vs x at any given value of A. Four such curves are shown at bottom left in Fig. A. The one at the far right

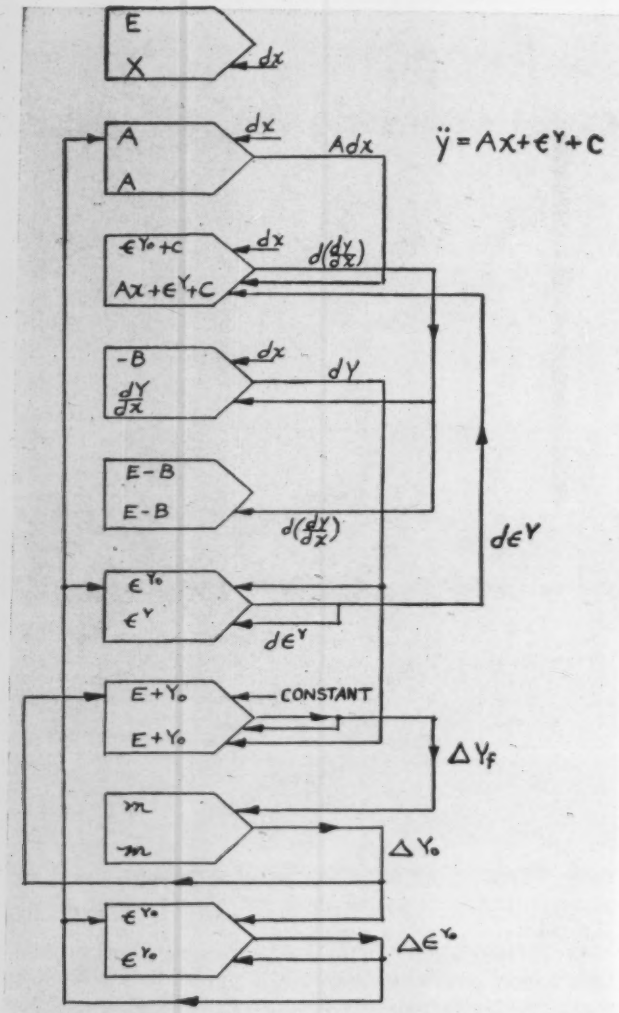


Fig. 11. Integrator diagram for solution of $\ddot{Y} = AX + e^{Y} + C$, with split boundary conditions.

is the desired solution. It is of interest to note that the computer can handle certain problems with singularities or discontinuities.

Nonlinear Differential Equations

In electrical and mechanical engineering, problems in simple harmonic motion are encountered. Such problems often are complicated by required use of a nonlinear damping function. An example is given in Fig. 9. The nonlinear differential equation to be solved, plotted and tabulated is shown in Fig. 9.

This was solved by use of 10 integrators. The initial conditions (shown as the top row of figures in the tabulated data) were that at $x = 0$:

$$d^2y/dx^2 = -2.10$$
$$dy/dx = 0.00$$
$$y = 2.10$$

The numerical solution of x over 14 units of y was tabulated in about six minutes of running time on the computer. A portion of the tabulated data is shown in Fig. 9, as is the curve automatically drawn by the plotter.

Evaluation of Integrals

Evaluation of integrals is a common physical problem. For example, in physical optics the *Fresnel Integrals* occur

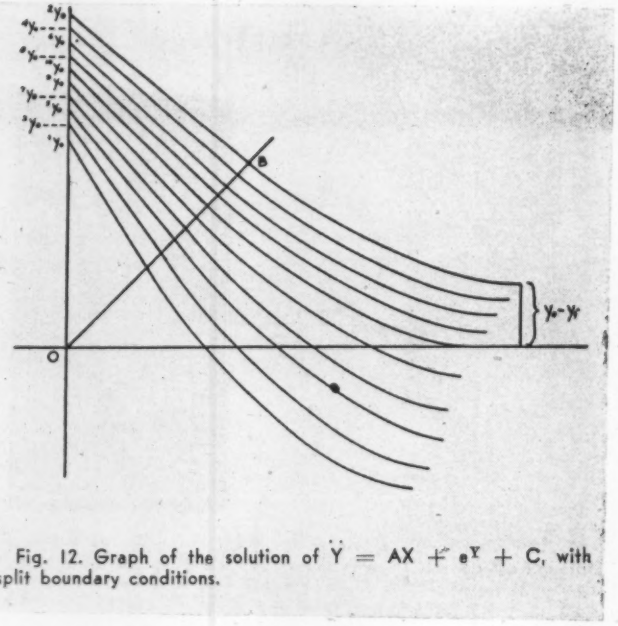


Fig. 12. Graph of the solution of $\ddot{Y} = AX + e^{Y} + C$, with split boundary conditions.

frequently. These integrals are shown in Fig. 10 and are ordinarily evaluated by use of infinite series. The DDA can make this evaluation either from a series or from the integrals directly. Eleven integrators were required to evaluate the integrals directly; as shown in Fig. 10.

The table in Fig. 10, taken from the computer, evaluates the integrals directly. The accompanying graph of y vs x, known as the Cornu spiral, was made by the graph plotter connected to the computer.

Split-boundary-value Problem

A new concept is embodied in the mode of handling initial conditions. Once set into the machine, they may be reset at any stage by pressing a button. Even more important, the conditions may be varied as a function of any of the variables and then reset automatically so that computation is restarted at a new point. An example is shown in Fig. 11. The differential equation

$$\ddot{Y} = Ax + e^{Y} + C$$

is given with boundary conditions

$$\dot{Y}_o = -B \ , \ \dot{Y}_f = 0$$
$$X_o = 0 \ , \ Y_f = 0$$

the problem being to find Y_o and X_f. The integrator diagram for this equation is first prepared (Fig. 11). The value of Y_o is estimated and set into the computer. Computation is then started.

Normally, Y_o is solved as one of a family of curves satisfying this equation. In addition, an error signal equal to Y_o is set into a servo.

The sum of the servo outputs is initially represented by that portion of the line OB extending from the origin to the curve Y (Fig. 12). This intersection represents the null position and, since incremental values of Y are being fed into the servo, the output now "follows" the curve of Y. The output of the servo up to and including the point where $Y = 0$ will, therefore, be equal to $Y_o - Y_f$. This output is first multiplied by a constant m, to reduce oscillations. The result is then used to generate e^{Y}, which is fed into the integrators holding e^{Y} as the initial condition of the next run. Computation is continuous until the boundary conditions are met, at which time the computer automatically stops. Solutions are shown in Fig. 12.

Process Control Analysis

This discussion on stability concludes this series on analysis of the closed-loop control system. A rapid and simple method for preliminary check of stability is application of Routh's criterion, which is shown applied to basic and typical control systems.

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VI. STABILITY

THIS study of process control would not be complete without an investigation of a method for determining quickly whether or not a system is stable. Let us first review briefly the current practice followed in the process control field for determining the stability of a controlled process.

Current Practice

In many applications, the process stability is evaluated on a trial-and-error basis. After the plant is constructed and the controller applied, the process is started up and the control engineer searches for the critical stability point by tuning in the controller with proportional control alone. When he finds the point at which the process continuously hunts or oscillates, he then has a starting point for determining what the optimum controller adjustments will be.

This procedure is not always practical. There is the possibility that allowing the process to cycle may produce damaging results on the plant and product quality. Another shortcoming of this procedure is that it sometimes becomes too time-consuming because of the excessively long oscillating periods of the plant. Utilizing this trial-and-error procedure also has the disadvantage that the plant may be unstable, regardless of the controller adjustments. The controller adjustments of α, β and γ have a limit as to their effect on the coefficients of the plant equations. These coefficients are made up of the process constants of resistances and capacities as well as the controller adjustments; in many cases it may be necessary to make a major alteration in the plant to obtain the degree of stable operation desired. The successful control engineer of the future will utilize procedures that will give information on stability *prior* to the construction of the actual plant. This will eliminate costly alterations and changes in plant design found necessary after the plant is built.

We are now going to apply a shortcut procedure to determine whether a system is stable or unstable. We will consider system equations which are of third order or higher (for systems which are of first or second order there can never be a possibility of instability as long as all of the coefficients of the system differential equation are positive).

Routh's Criterion

One method that is easy to apply is known as *Routh's criterion*. The method is applied to the coefficients of the system differential equations and does not require that these equations be solved. The method deals with explicit relations for the boundary between stability and instability, directly in terms of the system parameters.

The system parameters (constants) consist of the process resistances and capacities as well as the controller adjustments α, β and γ. In using Routh's criterion it is not necessary to evaluate the roots of a differential equation; however, if more complete data is desired on the degree of stability, it would be necessary to evaluate these roots. For equations of third order or higher, the labor involved in evaluating the roots and solving the differential equation becomes excessive, and in many cases it is desirable to investigate only whether or not the system is stable for a given design. Therefore, it is important to the control engineer to know of some procedure that can be applied to his design before actual construction of a plant that will give him information as to whether or not the system is going to be stable. Use of Routh's criterion is such a procedure, and will be described in terms of several typical controlled-process equations of third and fourth order.

Controlled Single-capacity Process with One Time-lag

Fig. 6-1 shows a single-capacity process with ideal (lagless) controller and valve system, but with time lag in the measuring system. When the controller has proportional plus derivative plus integral control action, the controlled-process equation is a third-order differential equation. This equation was determined in Chapter 3 (equation 3.1) and is repeated:

$$T_m H \frac{d^3x}{dt^3} + (T_m + H + R_q\beta) \frac{d^2x}{dt^2} + (1 + R_q\alpha) \frac{dx}{dt} + R_q\gamma\,(x - x_s) = 0 \qquad 6.1$$

where $T_m = R_m C_m$; $H = R_q C$; β = over-all derivative

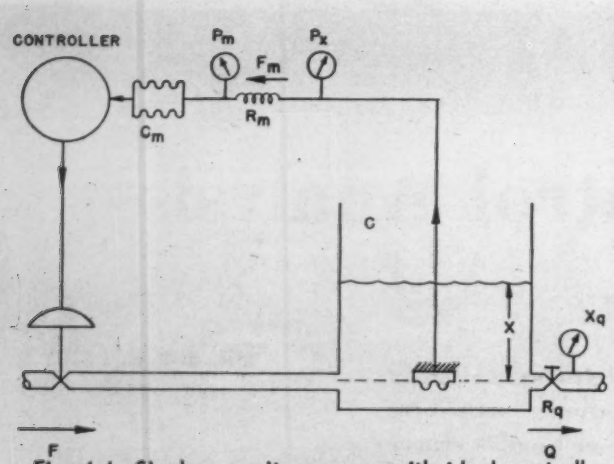

Fig. 6-1. Single-capacity process with ideal controller and valve, but with lag in the measuring system.

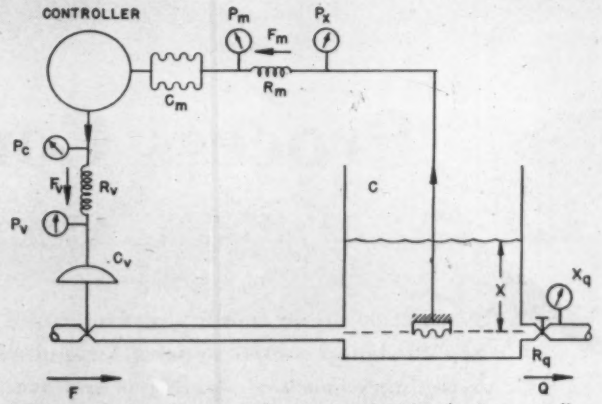

Fig. 6-2. Single-capacity process with ideal controller, but with lags in both measuring and valve circuit.

control factor; α = over-all proportional control factor; γ = over-all integral control factor; x = controlled level; x_o = desired level, or set point.

It is possible for instability to exist in the above system. Under certain conditions and for certain values of the coefficients of the differential equation, a disturbance to the system would result in a build up of oscillation amplitude. Practically, this amplitude would not build up to an infinite value because of physical restrictions in the controlled system; it becomes nonlinear and the oscillation will reach some maximum amplitude. Even so, this instability is intolerable for successful plant operation.

Conditions for Stability

The best method of understanding Routh's criterion is to apply it to a system differential equation such as eq. 6.1.

The *conditions for stability* for this third order system are two in number. First, all of the coefficients must be of the same algebraic sign. For convenience, let us rewrite eq. 6.1 as follows:

$$M_3\frac{d^3x}{dt^3} + M_2\frac{d^2x}{dt^2} + M_1\frac{dx}{dt} + M_o(x - x_o) = 0 \qquad 6.2$$

where $M_3 = T_mH$

$M_2 = T_m + H + R_q\beta$

$M_1 = 1 + R_q\alpha$

$M_o = R_q\gamma$

A second condition for the stability is:

$$M_1M_2 > M_3M_o \qquad 6.3$$

In almost all cases of process control the coefficients will be of the same algebraic sign so that the important thing to investigate is the inequality given in eq. 6.3. Inserting the actual system constants into the inequality above, and rearranging so that the integral control term is alone:

$$\gamma < \frac{(1 + R_q\alpha)\ (T_m + H + R_q\beta)}{T_mHR_q} \qquad 6.4$$

The inequality as written above allows us to investigate the controller adjustments as they affect the stability.

The above inequality shows the limiting conditions between stable and unstable operation. It can be determined that a system which is unstable can be made stable by any one of three of the following alterations in the controller itself:

(1) Decreasing the integral control factor, γ.
(2) Increasing the rate control factor, β.
(3) Increasing the proportional control factor, α.

If a system is checked by the inequality eq. 6.4 and does not test stable within the adjustments provided by commercial automatic controllers, then it can be made stable by altering the process resistances and capacities as is indicated in eq. 6.4.

Single-capacity Process with Lag in both Measuring Element and Valve

For the case of proportional plus derivative control, the characteristic equation for the system shown in Fig. 6-2 (as developed by equation 3.1 previously) is as follows:

$$M_3\frac{d^3x}{dt^3} + M_2\frac{d^2x}{dt^2} + M_1\frac{dx}{dt} + M_ox = 0 \qquad 6.5$$

where $M_3 = T_mT_vH$

$M_2 = T_mT_v + T_mH + T_vH$

$M_1 = T_m + T_v + H + R_q\beta$

$M_o = 1 + R_q\alpha$

$T_m = R_mC_m$

$T_v = R_vC_v$

Again, applying Routh's stability criterion, the conditions necessary for stability are (1) all the coefficients are of the same algebraic sign and (2) the following relationship is true:

$$M_1M_2 > M_0M_3 \qquad 6.6$$

This inequality is identical to equation 6.3, but after substituting the actual values of the coefficients of M_1 and M_0 which contain the controller constants of β and α respectively, we obtain:

$$M_2\ (T_m + T_2 + H + R_q\beta) > M_3\ (1 + R_q\alpha) \qquad 6.7$$

Reviewing the above inequality it will be found that: (1) An increase in β tends to make the system more stable. (2) An increase in α tends to make the system less stable.

From the above it is noted that the effect of the derivative response β is similar to its effect in the previous example. However, the effect of the proportional response α is now opposite from what it was before. This illustrates the fact that it *is not possible to generalize about the effect of a particular type of control too broadly.*

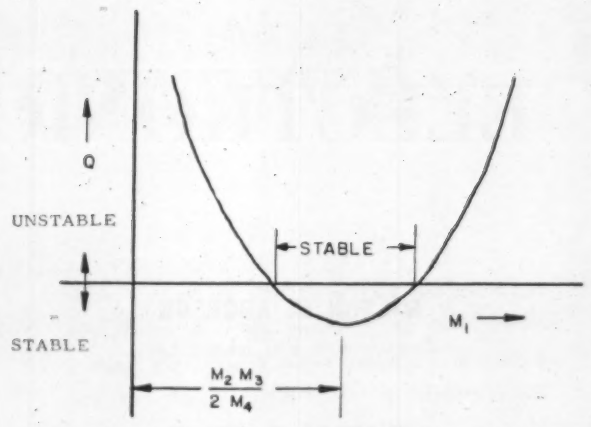

Fig. 6-3. Plot of Q (quadratic equation 6.17) versus coefficient M_1 shows the effect of α.

With Integral Control

If we include integral control to the system in Fig. 6-2, a fourth-order equation will be obtained. The system characteristic equation for this case is:

$$M_4 \frac{d^4x}{dt^4} + M_3 \frac{d^3x}{dt^3} + M_2 \frac{d^2x}{dt^2} + M_1 \frac{dx}{dt} + M_0 x = 0 \qquad 6.8$$

where $M_4 = T_m T_v H$

$M_3 = T_m T_v + T_m H + T_v H$

$M_2 = T_m + T_v + H + R_q \beta$

$M_1 = 1 + R_q \alpha$

$M_0 = R_q \gamma$

Applying Routh's criterion, the conditions for stability are *three* in number. First, all of the coefficients must be of the same algebraic sign. The second and third conditions are, respectively:

$$M_1 M_2 M_3 - M_1^2 M_4 - M_0 M_3^2 > 0 \qquad 6.9$$

and

$$M_2 M_3 > M_1 M_4 \qquad 6.10$$

Rearranging 6.9:

$$M_1 (M_2 M_3 - M_1 M_4) > M_0 M_3^2 \qquad 6.11$$

The system can be unstable if either condition 6.10 or 6.11 is not fulfilled; 6.11 is a necessary and sufficient condition for stability while 6.9 is necessary but not sufficient. Rearranging Eq. 6.11 we obtain

$$M_1^2 M_4 - M_1 M_2 M_3 + M_0 M_3^2 < 0 \qquad 6.12$$

At the threshold of stability the above relation just equals zero, so we can write

$$M_1^2 - \left(\frac{M_2 M_3}{M_4} \right) M_1 + \frac{M_0 M_3^2}{M_4} = 0 \qquad 6.13$$

the roots of M_1 are:

$$M_1 = + \frac{M_2 M_3}{2 M_4} \pm \sqrt{\left(\frac{M_2 M_3}{2 M_4} \right)^2 - \frac{M_0 M_3^2}{M_4}} \qquad 6.14$$

Inspection of 6.14 shows that for M_1 to have any real roots it is required that

$$\left(\frac{M_2 M_3}{2 M_4} \right)^2 \geq \frac{M_0 M_3^2}{M_4} \qquad 6.15$$

or, writing in a different manner:

$$\frac{M_3^2}{M_4} \left(\frac{M_2^2}{4 M_4} - M_0 \right) \geq 0 \qquad 6.16$$

Plot of Eq. 6.13 to show Effect of α

Setting the value of the quadratic eq. 6.13 equal to Q, we obtain

$$M_1^2 - \left(\frac{M_2 M_3}{M_4} \right) M_1 + \frac{M_0 M_3^2}{M_4} = Q \qquad 6.17$$

A graph of M_1 vs. Q will show the effect of M_1, which contains the coefficient α, on the boundary of system stability when all other constants are unchanged. This graph is shown in Fig. 6-3.

Effect of γ and β

The effect of integral response, which is contained in the M_0 coefficient, is disclosed in eq. 6.16. Here it is apparent that for stability to exist the following inequality must be satisfied

$$M_0 < \frac{M_2^2}{4 M_4} \qquad 6.18$$

Substituting the actual value of M_0 gives

$$\gamma R_q < \frac{M_2^2}{4 M_4} \qquad 6.19$$

which shows that the amount of integral response must always be of a value that will satisfy eq. 6.19, or the system will be unstable.

The coefficient M_2 contains the rate response β which, if changed, can act to satisfy equation 6.19 if control is somewhere near the proper range.

To summarize the above findings, we can state the following effects on a system of this type which is barely stable or on the verge of being unstable:

(1) Increasing the integral response tends to make the system more unstable.
(2) Increasing the rate response tends to make the system more stable.
(3) Increasing the proportional response tends to make the system more stable or less stable, depending on the values of the coefficients.

Other Cases

We have shown the application of Routh's criterion to three cases of process control, including third- and fourth-order systems. These examples demonstrate the application of the criterion as used to determine whether or not a given control system is stable. Note that the criterion is of value as a *preliminary check* on a given design and does not yield *quantitative* data as to the degree of stability. Although the method involves some labor in the higher-order systems, it is still considerably more rapid than attempting to evaluate the roots of the characteristic equation. After a system has proved stable by the Routh check, it would be practical to make a more detailed analysis of the problem by evaluating the roots and determining the response curve. This will give an exact picture of the plant performance that can be expected.

This concludes this important and timely series on Process Control Analysis. The entire series, plus conclusion and extensive bibliography, soon will be available in cloth-bound book form. Watch for announcement.

ELECTRONIC

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Instruments Publishing Co.

and

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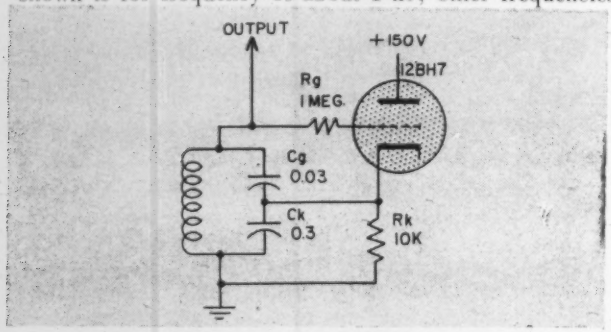
Potter Instrument Co.

MODIFIED-HARRIS LC OSCILLATOR

Commonly used single-tube oscillator circuits require a tapped inductor, which often must be specially designed. This oscillator is simpler than other circuits which use a two-terminal inductor, and is said to be inherently stable, vigorous, and non-critical as to circuit constants. Circuit shown is for frequency of about 1 kc; other frequencies



in the audio and low r-f range may be obtained by changing the tank constants. Best waveform and stability are obtained when ratio of C_k to C_g is about 100; largest ratio that will sustain oscillation is function of the resonant impedance of the tuned circuit. Smaller ratios of C_k to C_g (in order of 4 to 10) produce larger output. Output decreases with increased cathode resistance R_k, and is directly proportional to supply voltage. R_g may be omitted.

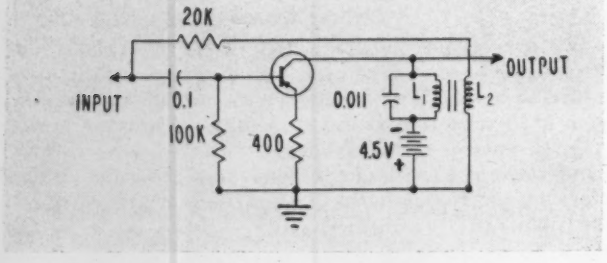
Circuit shown uses one-half of a 12BH7; almost any tube may be used, including pentodes as electron-coupled oscillators. Optimum R_k is lower for higher-mu tubes. For example, R_k is 4.7K for ½ of a 12AT7.

Output of circuit shown: 35 v rms; plate current is 2 ma; Q of inductor is 20.

Source: L. Fleming, Electronic Engineering and Service Co., Inc., Falls Church, Va.; also *Electronics*, March, 1955.

TUNED TRANSISTOR AMPLIFIER

Positive feedback (for high selectivity) and negative feedback (for stability) are used in this single-transistor (CK721) 10-kc tuned amplifier. Positive feedback at 10 kc is obtained by a resonant transformer (transformer details are given below). Negative feedback at all frequen-



cies is provided by the 400-ohm resistor in the emitter circuit. Value of resistor between L2 and input determines amount of positive feedback; it is chosen to keep the feedback below that which would cause oscillation. Resistor in emitter circuit determines the negative feedback and the selectivity of the circuit.

Selectivity: ± 150 cps at 3 db points.

Voltage gain: 76.

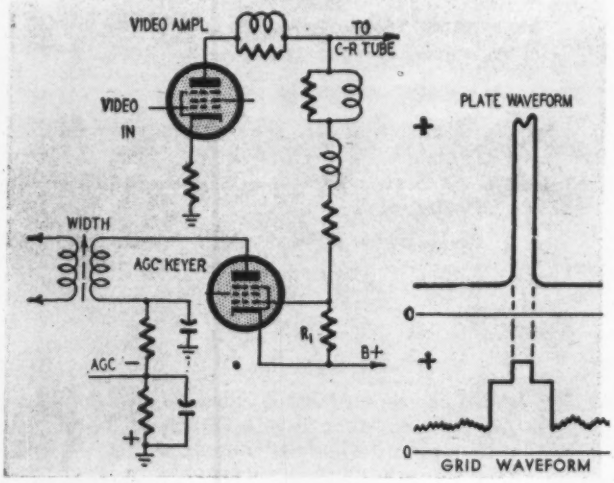
B supply: 4.5 v dc at approx. 100 ma.

Transformer details: Core, Arnold toroid, 1.35″ OD, 0.92″ ID, 0.35″ high; Primary L_1, 18 mh, Q of 80, 460 turns; Secondary L_2, 0.1 mh, 25 turns; Wire, 0.2 mm copper enamel.

Source: D. Bier and S. Rosen, *Electronics*, Dec., 1954.

KEYED AGC

Development of an AGC (automatic gain control) signal for a TV receiver is a problem. Conventional filter-type circuits won't work because (1) noise pulses are similar to the video signals—hence a noisy signal will develop more AGC and weaken an already weak signal, and (2) fading and airplane flutter causes slow variations that



must be smoothed out. The video pulses require a fast-acting AGC circuit, but a fast-acting filter would permit the AGC circuit to react to the long vertical sync pulse, which is not desired.

The solution is to use a fast-acting AGC circuit that is gated, or keyed, to react only to the horizontal sync pulses. This is done by feeding the composite video signal (from the video amplifier) to grid of the AGC keyer tube (6AU6 pentode). The voltage drop across R1 in plate load circuit of video-amplifier-stage holds keyer cut off—except at the instant that a 300 to 500 volt signal is applied to plate of keyer from horizontal output circuit. At this same instant, the horizontal sync signal reaches grid. Hence average plate current of keyer depends only on level of horizontal sync pedestal. Pentode is used as keyer because pentode current is relatively independent of plate voltage and depends only on grid signal. Keyer is gated 15,750 times per second.

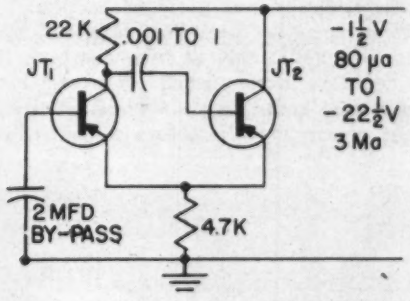
Source: *Radio-Electronics*, Nov. 1954.

CIRCUITRY

The circuit is the heart of all electronics. Here are six more basic and interesting circuits. Unless marked, resistors are in ohms, capacitors in microfarads.

TRANSISTOR MULTIVIBRATOR

This emitter-coupled multivibrator is analogous to the familiar cathode-coupled vacuum-tube free-running multivibrator. Operation at low supply voltages is made possible because circuit has high loop-gain at frequencies below the alpha-cutoff of the transistors (circuit operates at 1.5-volt supply with 80-uamp drain).



TI-201, TI-904, and CK-722 transistors have been used. TI transistors permit operation to higher frequencies, but silicon TI-904 requires at least 3-volt supply. Note that only two resistors and two capacitors are used.

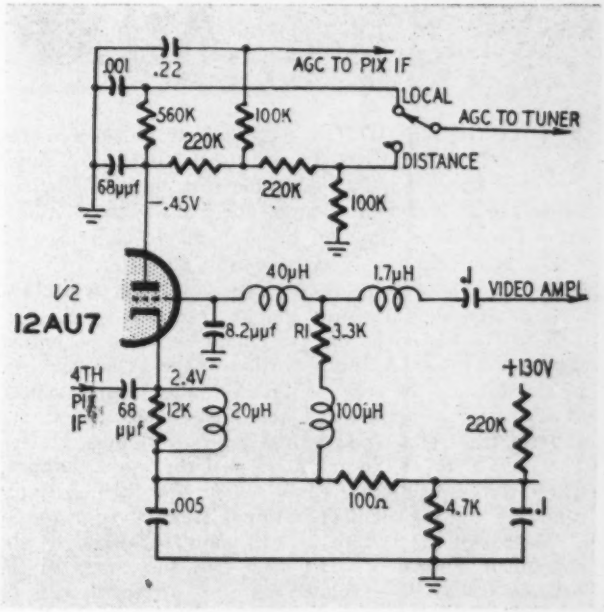
Pulse-repetition frequency can be varied from 6 to 6000 per second by varying coupling capacitor from 1 to 0.001 uf. Operation with TI-904 silicon transistor permits operation to 500 kc, with pulse rise time of 2 usec. New TI-X59 (now available; new designation to be applied), especially designed for pulse and switching circuitry, has upper frequency cutoff of 5 Mc minimum.

Power Supply: 1.5 v at 80 uamp; 7½ v at 0.3 to 1 ma, depending on bias resistor; 22½ v at 3 ma.

Source: Frank C. Alexander, Jr., Gulf Research and Dev. Co., Pittsburgh 30, Pa.; also *Electronics*, Dec., 1954.

TRIODE BECOMES DUAL DIODE IN AGC CIRCUIT

In the Arvin TE331 TV receiver, final pix i-f signal is fed to cathode of ½ of a 12AU7. The grid acts as the anode of a diode detector; detected envelope of i-f signal

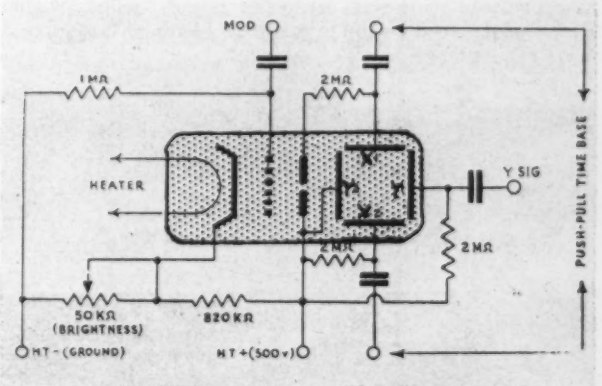


(the video signal) appears on grid. Plate of 12AU7 also acts as anode of diode detector, developing AGC signal. Hence triode functions as dual-diode detector. Cathode and grid are at d-c level of 2.4 volts, so i-f signal must exceed 2.4 volts before AGC signal develops.

Source: *Radio-Electronics*, Nov., 1954, page 32.

MONITOR OSCILLOSCOPE

Type 1CP1 miniature cathode-ray tube is used in this simple oscilloscope circuit, which may be built into complex electronic gear for monitoring circuit waveforms. Type 1CP1 requires no focus control and no special



heater supply (heater to cathode potential may be as high as 250 volts). Screen diameter is one inch. Only one anode potential is required; up to 800 volts may be used. Push-pull sweep voltage is required; deflection signal input is single-ended.

Anode voltage: 500 v dc.

X-deflection sensitivity: 0.18 mm/volt (5.5 v/mm).

Y-deflection sensitivity: 0.22 mm/volt (4.5 v/mm).

B supply: 500 v dc at less than 1 ma.

Heater: 6.3 v ac at 600 ma.

Source: A. C. Cossor Ltd., Cossor House, Highbury Grove, London, N.5. England.

Distribution Control of

MIXED GAS

GAS DISTRIBUTION SYSTEM at Fairless Works is U shaped (Fig. 1), consisting of about 2 miles of 36-inch and 30-inch line with the end portions swaged to 24-inch and 20-inch. The plant of the National Tube Division is supplied through an 18-inch take-off.

The base fuel supply is coke-oven gas from two batteries. The gas is compressed by steam turbine boosters to the normal system pressure: 9½ to 10 psi.

Note that the coke-oven gas enters the main on one of the legs of the U. A minor portion of the gas is required by facilities on the end portion of this leg, being utilized as drying gas in open-hearth and blast-furnace operations, and for pilot and standby fuel for power-house boilers. The remainder of the gas flows past the mixing station, where stabilized natural gas is added, and then on to the mill area and the plant of National Tube Division.

Control of the system, as originally furnished by the coke-plant contractor, was such that the speed of the booster would be regulated by line pressure, with an override from the position of a gas holder installed upstream from the booster station.

From fuel balance calculations it was apparent that an auxiliary gaseous fuel would be necessary when all consuming units under construction were placed in operation. Negotiations for a natural-gas contract were begun and the plans for a mixing station were formulated.

Problems in Mixing Gases

In the early stages of the "start-up" of the plant more coke-oven gas was produced than was required, because of the low mill load. Operations of the gas-distribution system were fairly smooth because the gas holder was raised to bleed position and the system was controlled by line pressure. However, when the larger fuel-consuming units were placed on the line, the problems of fuel mixing were encountered.

As the finishing-mill capacity exceeds the capacity of the steel-making facilities at Fairless, continuous operation of all units is not maintained, which causes a fluctuating load on the fuels system. It would be impossible, under these conditions, to maintain combustion control by injecting pure natural gas into the main. Due to the fluctuating mill load, the gas delivered to the consumer could contain from zero to approximately 100 percent natural gas. This would cause the BTU content and the specific gravity of the mixture (which together determine the heat input) to vary over a wide range.

Heat Flow Factor

The heat flow factor, or Noy Formula (or, as it is called in England, "Wobbe Index") is derived from the basic formula of flow through pipes to represent the heat input through an orifice or burner and, therefore, the demand for combustion air. It is found by dividing the BTU content of a gas by the square root of the specific gravity.

The mixing problem is illustrated by Table 1. Note that the coke-oven gas sample has a BTU content of 565 per scf, and a specific gravity of 0.355; giving a heat flow factor of 950. The natural gas has a constant BTU content of 1060 and a specific gravity of 0.60, giving a heat flow factor (K) of 1370.

With this varying heat flow factor, the proper operation of metering installations and fuel-air ratio controls becomes impossible because the differential across an orifice varies with the change in specific gravity. For this reason a station was designed to permit gas mixing so as to keep the heat flow factor of natural gas constant and equal to that of coke-oven gas. It was felt that this could be accomplished by mixing air with the natural gas, thus reducing the BTU content and raising the specific gravity, which in turn would reduce K.

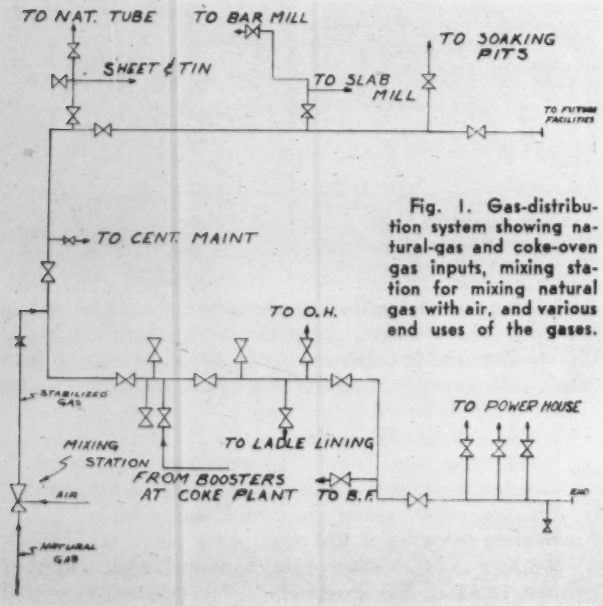


Fig. 1. Gas-distribution system showing natural-gas and coke-oven gas inputs, mixing station for mixing natural gas with air, and various end uses of the gases.

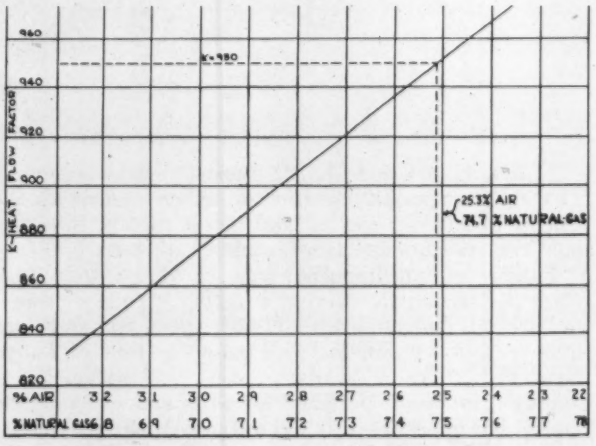


Fig. 2. Heat flow factor vs. gas-air ratio.

JACK E. WEBBER

Fairless Works, U. S. Steel Corp.

Control of extensive steel-mill mixed-gas system involved inter-related control of pressures, flows, heat flow factor, booster speed, and holder position. Discussed are the basic problems, initial systems, required revisions, and results. Heat-flow-factor control proved important.

Table 1.—Chemical Analysis and Heat Flow Factor for Coke-oven and Natural Gas at Fairless Works.

Coke-Oven Gas		*Natural Gas*	
H_2S	0.7	H_2	0.0
CO_2	1.4	CO	0.0
ILL	2.6	CO_2	0.8
0_2	0.5	CH_4	92.8
CO	5.4	C_2H_4	0.0
CH_4	30.2	C_2H_6	4.1
H_2	56.0	C_3H_6	0.0
N_2	2.8	C_4H_8	1.2
C_2H_6	0.4	n-C_4	0.2
	100.00%	N_2	0.9
			100.00%
Specific Gravity	0.355	*Specific Gravity*	0.603
BTU	565	BTU	1060
K	950	K	1370

Control of Heat Flow Factor

From Fig. 2 it can be seen that the desired flow factor of 950 can be maintained by injecting a mixture consisting of 74.7% natural gas and 25.3% air by volume.

Natural gas at 125 psi was available. Therefore, it was decided that a jet compressor station which would utilize the energy of 75-psi gas to compress the necessary air and force the resultant mixture into the fuel system would be the most efficient and economical method.

The station consisted of 15 jets in three batteries of 5 each. Each jet was capable of passing 100,000 cubic feet per hour of natural gas at 75-psi upstream and 10-psi downstream pressure, and compressing with it a maximum of 42,000 cubic feet per hour of air.

Original Control of Mixing Station

As originally designed (Fig. 3) the pilot mechanism consisted of a pressure controller and valve, the controller receiving its impulse from a change in pressure in the gas main. Assuming a drop in pressure, indicating a need for gas, the regulator would cause the valve to open, delivering undiluted natural gas into the line at a maximum rate of 150,000 cubic feet per hour.

When the valve reached a completely open position, it operated an air relay which transmitted two signals—one signal actuated a pilot valve on the first jet, causing it to open; the second signal is sent back to the pressure controller, causing it to partially close. When the jet was completely open, two more air relays were actuated, one opening a diaphragm valve in the dilution-air intake ahead of the jet, the other allowing the next "increase" impulse to bypass the open jet control and actuate the second jet.

If the pressure in the main continued to drop, the controller valve would return to the full open position, again transmitting the "increase" signal, causing another jet to open. In this manner, the full 15 jets could be used in sequence. When the line pressure again reached the desired point, the inverse would occur. The pressure controller valve would return to a closed position, transmitting a "decrease" signal, which in turn would cause a jet to be removed from the line. Then, if further reduction in volume was indicated by the line pressure, the controls would continue to remove jets from service. The mixing station was put into service with this control system.

Revised Mixing-station Control

Owing to the extreme fluctuations in the fuel load, it was immediately apparent that more sensitive control was required. In attempting to increase the speed of the controller, several types of relays and pilots were placed ahead of the controller in order to magnify the impulse transmitted by a smaller change in line pressure. Operations were improved somewhat by these modifications.

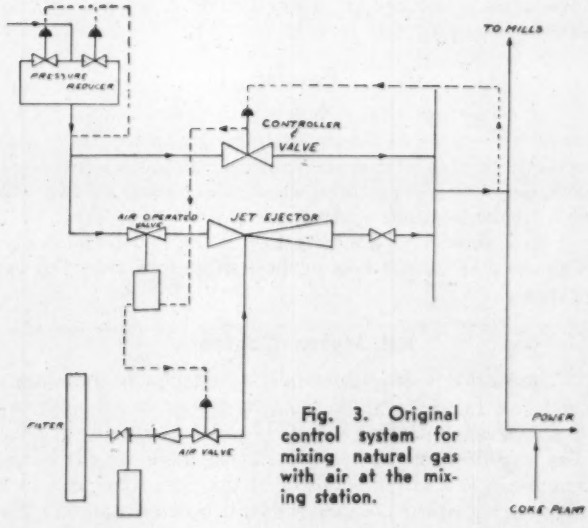


Fig. 3. Original control system for mixing natural gas with air at the mixing station.

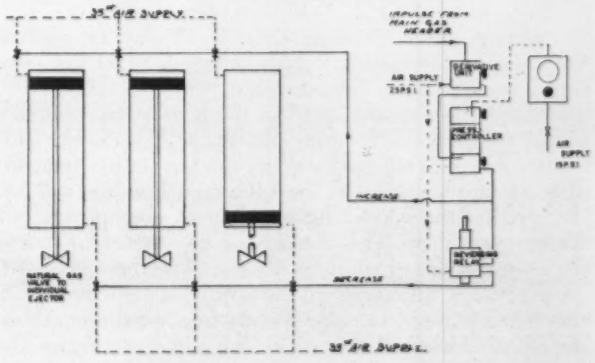


Fig. 4. Revised mixing-station control system.

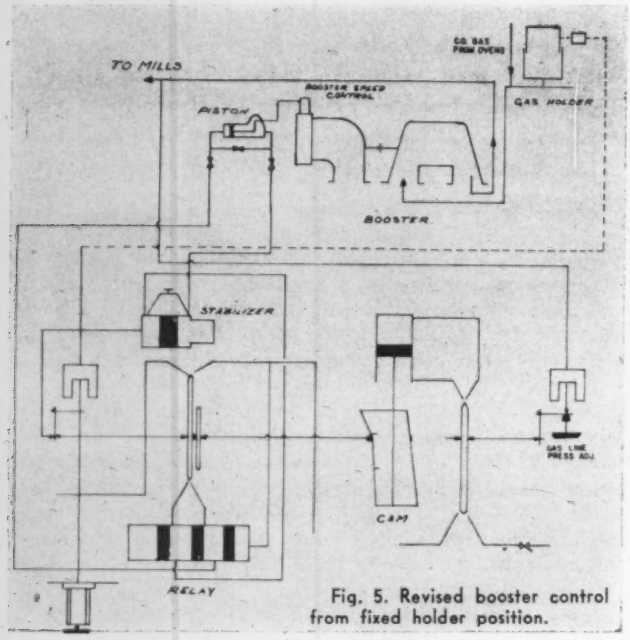


Fig. 5. Revised booster control from fixed holder position.

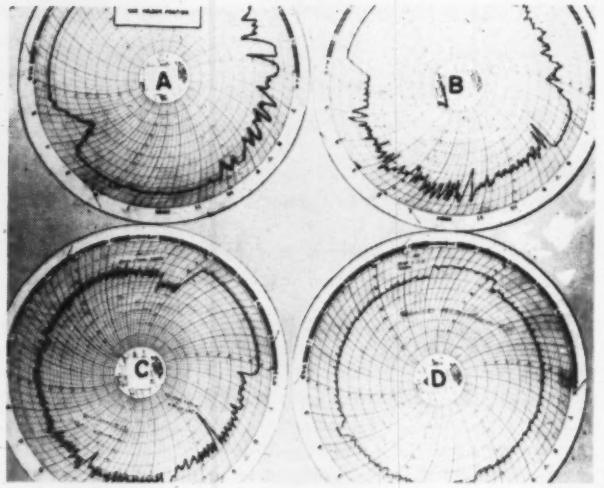


Fig. 6. Charts showing holder travel (a) prior to mixing station, (b) with original mixing-station control, (c) with derivative control of mixing station, and (d) with holder-position control of booster.

However, it appeared that the lag introduced by any type of intermediate control valve ahead of jet control proper had to be eliminated. The problem of direct control of line pressure from the operation of the jets then was considered.

The revised mixing-station control is shown in Fig. 4. The main-gas-header pressure is fed into a derivative unit which produces a signal proportional to the *rate* of gas pressure in this header. This rate signal is sent to a conventional pressure controller. From this unit the signal is transmitted to the "jet increase relay," and to one side of a reversing relay. A signal is transmitted from the other side of the reversing relay to the "jet decrease relay." When pressure conditions on the gas header are satisfied, the signals on each side of the reversing relay are balanced. As both the increase and decrease jet relays operate at about 9 psi, the almost instantaneous operation of air loading from 5 to 9 psi has replaced the controller valve with its inherent lag. With this control system, mixing-station operations have been well established.

Over-all System Control

At this time there were three separate controls on the system—(1) line-pressure control of the boosters, (2) holder-position override to the booster control, and (3) the mixing-station pressure control. The major control exercised by the mixing station caused a slight but continual fluctuation in line pressure, which had a highly magnified effect on the speed of the booster and the gas-holder position. If, for example, the mill load was suddenly increased, not only did the mixing station immediately go into operation to meet the increased demand but the speed of the booster increased in an attempt to offset the pressure drop. This caused the gas holder to fall to the low position, which in turn reduced the booster speed. As practically all coke-oven gas available for outside use was being pumped into the system, in normal operations, the effect of a small change in line pressure affected the booster and holder far out of proportion with their capacity to correct the situation. Therefore, it was decided to control the speed of the booster from a fixed holder position, allowing the booster to deliver only the total amount of coke gas available for outside use, regardless of changes in mill load.

Revised Booster Control

This change (Fig. 5) to the existing control was accomplished by reversing the impulse lines from the pressure control and the holder-position override, and by reversing the transmission lines from the front of the controller.

After the various revisions described above, the system is operating in essentially this manner:

1. A conventional holder-position control on the coke-plant booster with a high-pressure override that will reduce the speed of the booster and allow bleeding of excess coke gas.

2. Control of line pressure by the mixing station, utilizing a common derivative unit followed by a pressure controller and reversing relay.

Mill operations are scheduled so as to utilize all available coke-oven gas. In addition, the mixing station has supplemented this supply by as much as the full capacity of the station (15 jets or 1,500,000 cubic feet per hour of natural gas). The minimum gas contract allows enough gas to maintain line pressure from the station while certain large consumers are using Bunker C oil during curtailed gas supply due to cold weather.

Results

Fig. 6 has four charts showing the percentage of holder travel (a) prior to mixing-station installation, (b) with original mixing station control (mechanical pilot), (c) with derivative differential air loading control, and (d) with holder-position control.

Fig. 7 shows the line pressure at the booster and Fig. 8 shows the mill gas flow at these same four stages of operation.

K Meter Control

The station was set manually to attempt to maintain a heat flow factor corresponding to design on all plant orifice meters, which was 560 BTU and 0.37 specific gravity. The variables at the mixing station were weight of air (humidity), and temperature of the gas. After considerable testing of the coke-oven gas, it became apparent that the heat flow factor of the gas was varying as much as 10 percent from the original average figure.

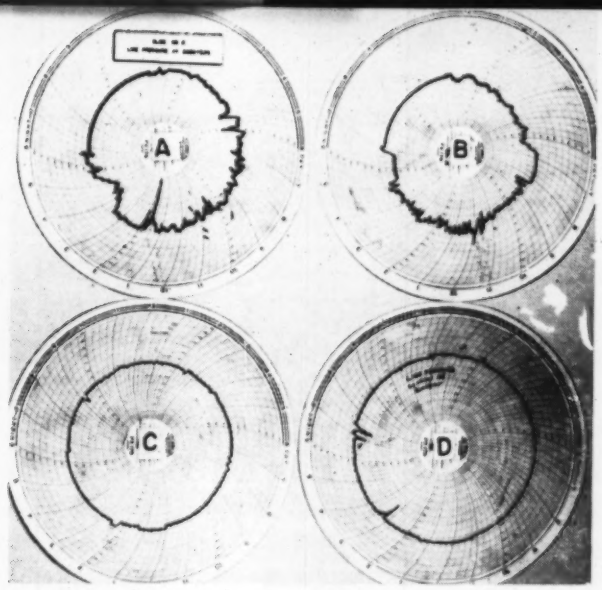


Fig. 7. Line pressure at booster for the four conditions of Fig. 6.

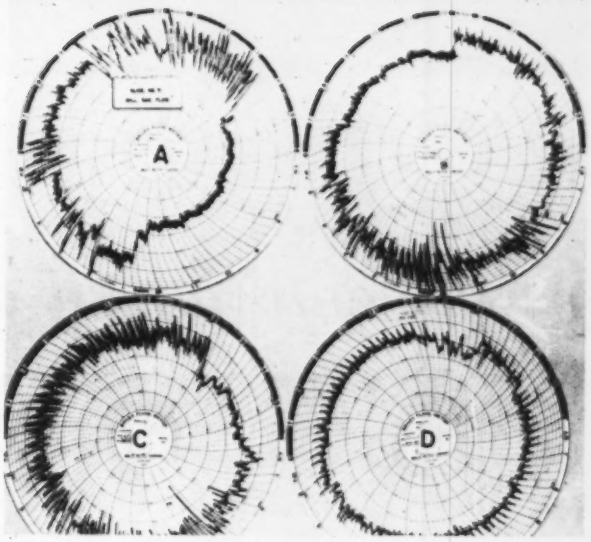


Fig. 8. Mill gas flow for the four conditions of Fig. 6.

Combustion checks throughout the mill confirmed this. Some of the smaller, more critical burners had shown evidence of the critical nature of this heat flow factor. In checking available measurement and control devices, it was found that the true picture of heat flow conditions could be represented only by a combined record of a calorimeter and a specific-gravity meter. Since this in effect gives heat flow factor, it was felt that a heat-flow-factor meter, (a K meter with a transmitter) would rectify the error of varying heat flow factor more than any other device. The plan for the immediate future is to install a K meter on the mill side of the mixing station intersection, and to use the air capacity of the jets to control the heat flow factor of the resultant mix of coke-oven gas, natural gas, and air. The limitation imposed by such control is the low load which exists at certain times on the mixing station, thus limiting both the amount of air or natural gas available to temper the coke-oven gas as needed. It is felt that the coke-oven gas could be stabilized satisfactorily with either jets or a small blower ahead of the boosters; an investigation is under way to explore the feasibility of such an installation.

It is also planned to install heating coils in the incoming air headers at the mixing station in order to prevent freezing in the jets, a condition which has occurred several times during periods of high humidity and low temperature.

The only other problem which the gas system has imposed is the difference in flame characteristics between that of coke-oven and natural gas. Burner experiments have been concluded, and data indicate that on the smaller burner installations (where these flame characteristics are important) a modified burner can be used to attain the desired result.

Control Panels

All fuels handling, ordering, and dispatching is accomplished from an office in the mixing station by a Fuels Dispatcher Foreman. There is also a mixing station operator who watches operations from the room which houses the control panel (Fig. 9). The Fuels Dispatcher also supervises maintenance of oil and gas lines, allocation of fuels, ordering and receiving fuel oil, operation and maintenance of the Bulk Fuel Oil pump house, and the Hot Strip Mill pump house.

In conclusion, the mixing station and system have proved satisfactory. The control system permits the handling of varying gas quantities, mixing, and stabilizing. Using the gas energy as the compressor medium has proved flexible, efficient, and economical.

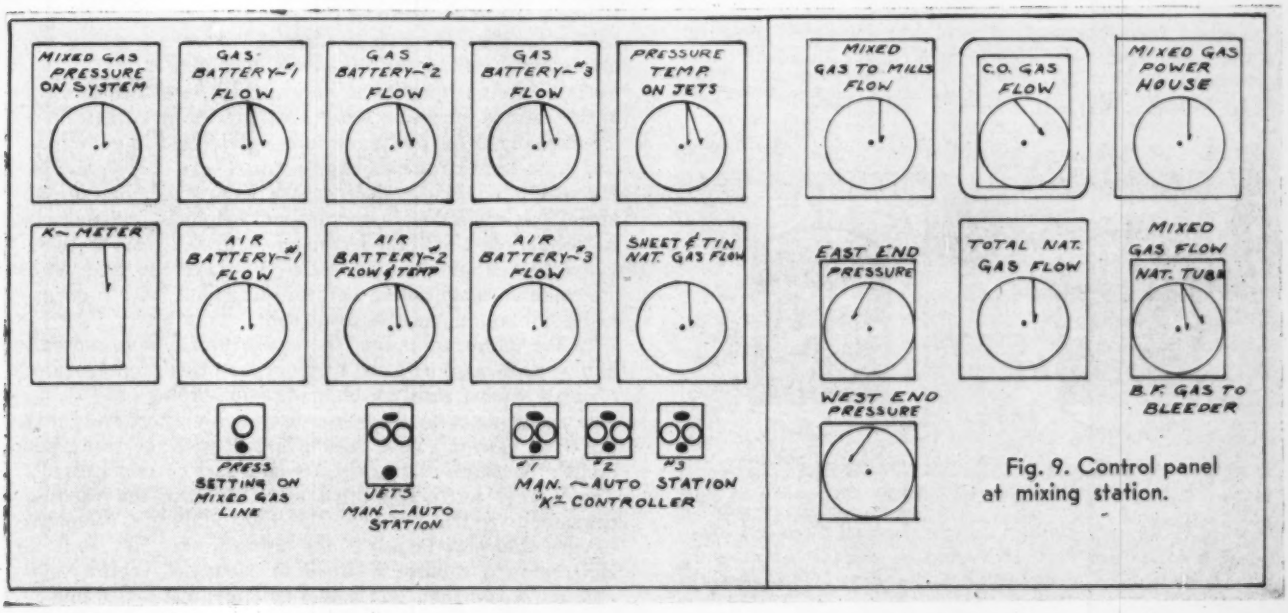


Fig. 9. Control panel at mixing station.

Instrumentation of a
DEMINERALIZING PLANT

An automatically-controlled demineralizing plant produces 1 million gallons of demineralized water (the purest water known to man) and 7 million gallons of clarified water, daily, for tin-plate production. Instrumentation makes possible this low-cost high-volume production with only two operators. But still needed are better methods for proportional feed of dry chemicals and for detection of cation-unit exhaustion.

E. J. TILLY
Jones & Laughlin Steel Corp.

WHEN Japan struck Pearl Harbor, it became immediately apparent that the free world had to conserve its supply of virgin tin metal. The steel industry had to reduce the consumption of tin used in food containers to an irreducible but safe minimum. This was done by converting from hot-dip-tinning process to electrolytic tin-plating process. This conversion, costing millions of dollars, made it possible for the canning industry to pack foods safely in containers coated with 0.25, 0.50 and 0.75 pound of tin per base box, compared with a previous figure of 1.25 to 1.50 pounds of tin per base box.

It was found that the new product required the best water available for use in the electrolytes and the post-plating processes. We turned to steam condensate which, in boiler operation, means (1) increased blow-down, (2) increased fuel consumption, and (3) increased make-up water consumption—which in turn causes increased operation and maintenance cost. However, the demands of new processes had to be met.

Presented at Conference on Instrumentation for the Iron & Steel Industry, Pittsburgh, March 25, 1954.

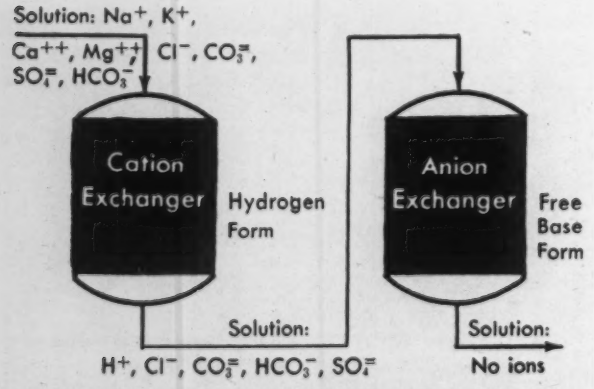


Fig. 1. In multiple-bed deionization all dissolved ionizable solids are first converted to mineral acids and then neutralized in the anion exchanger to form water.

Why is this high-quality water necessary? One ton of tin plate provides ends for 90,000 food containers (tin cans). Multiply that by the average family of three, and you wind up with 270,000 people eating out of containers made from one ton of tin plate. As we produce a maximum of 32,000 tons of tin plate in one month; there must be no compromise in quality standards; pure water was necessary.

Evaporators were impractical because of high initial and operating cost. The answer was a demineralizer.

Demineralizer

What is a demineralizer?

It is simply a three-stage chemical process in which we first convert all of the dissolved ionizable solids in the water to their respective mineral acids. As shown in Fig. 1, the cations (metallic ions) entering the first resin bed are exchanged for hydrogen ions lightly held in combination with the cation-exchange resin. These are typical of the reactions taking place in the first stage, or cation, units. Calcium chloride, magnesium sulphate, and sodium carbonate react with the hydrogen-saturated resin to form hydrochloric acid, sulphuric acid and carbonic acid, with the calcium, magnesium, and sodium being held in chemical combination on the resin bed.

In the anion exchanger the hydrochloric acid and sulphuric acid react with the hydroxyl-saturated anion resin, forming water, with the chloride and sulphate ion being held in chemical combination on the anion bed. Note that the weak carbonic acid does not react with the resin, but readily breaks down to form water and carbon dioxide. This brings us to the third and last step, the vacuum degasifier, which removes the CO_2 and any dissolved oxygen that may be left in the anion water. The result is H_2O, plus a minimum trace of elements, whose total amount is less than that found in triple-distilled water.

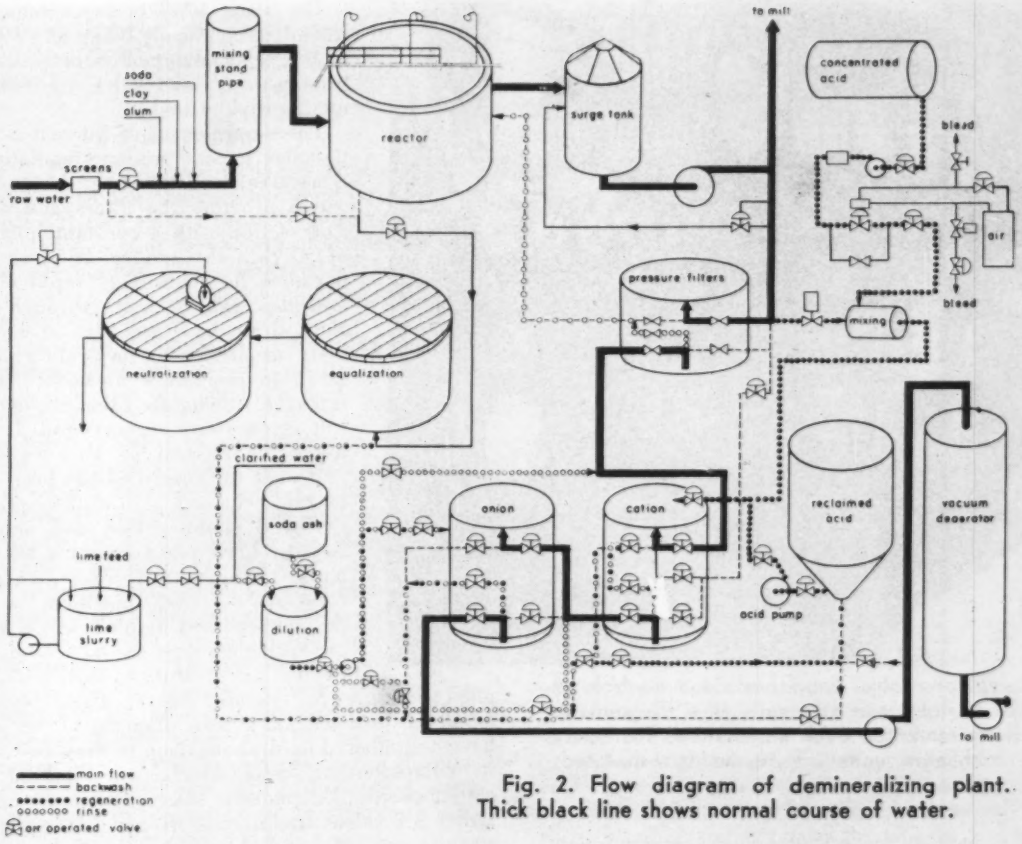


Fig. 2. Flow diagram of demineralizing plant. Thick black line shows normal course of water.

Fig. 2 shows how our plant is arranged. The thick black line shows the normal course of water from the discharge side of our South Mills pumping station on the river bank (upper left), and follows through the process to the outlet of the vacuum deaerator, from which it is pumped directly to the tin-plating facilities in the mill.

Water Flow

We first screen out larger materials, such as fish and leaves, in three Hellan strainers. We next add our coagulation chemicals (sodium hydroxide, clay and alum) and then the water enters a mixing standpipe. From here the water goes to two 2,500-gpm Cochrane sludge-contact up-flow clarifiers, or reactors, where we filter the turbidity out of the water by suspending a blanket of sludge in the slowly rising water. This turbidity will vary from 10 to 1000 ppm. This method of filtering water requires close control of the density of this sludge blanket. One of our main aims in density control is to make it as insensitive as possible to changes in up-flow rate of water. We are pleased with this equipment; we have been able to carry water loads of 150 percent of designed capacity, and still produce water with a turbidity ranging from 2 to 5 ppm, expressed as SiO_2—that is, it appears crystal clear to the naked eye.

From the reactor the water passes into a 50,000-gallon surge tank. At this point the flow divides, and we supply the mill with a rated flow of 4,250 gpm of this clarified water for various processes. The balance of the water then flows through pressure sand filters where the turbidity is reduced to practically zero in order to protect the ion-exchange resins.

The cation units convert the mineral salts to their respective mineral acids; the anions absorb the acid radical; and the degasifier removes the CO_2 that comes from the disassociation of the weak carbonic acid and any dissolved oxygen. This part of the plant is rated to produce 750 gpm of demineralized water with a conductivity not exceeding 22 micromhos.

The plant normally produces water with a conductivity ranging from 3 to 8 micromhos (equivalent to an electrical resistance of 200,000 ohms). This water is also used in a closed recirculating cooling system on our 1,800-kw high-frequency reflow brightener in the electro-tinning lines. Here this water is subject to voltages ranging to 17,000 volts, with no apparent current leakages. (This one of three brighteners has the equivalent broadcasting power of 36 radio stations like KDKA—yet we are not allowed to "peep" over the air waves.)

Instrumentation

Instrumentation makes this process possible. We will first cover the instruments used in the normal flow of water; then the controlling equipment used in regenerating the cation and anion resins; and then the waste-product disposal.

The Cochrane up-flow reactors are controlled by two recording flowmeters which receive their impulses from transmitters in the strainer house. These transmitters send information from orifice flanges just upstream of the two Cochrane reactors. The flowmeters feed flow-rate information into a totalizing meter. The totalizing meter controls the following:

First, chemical feed rates of the two operating Wallace

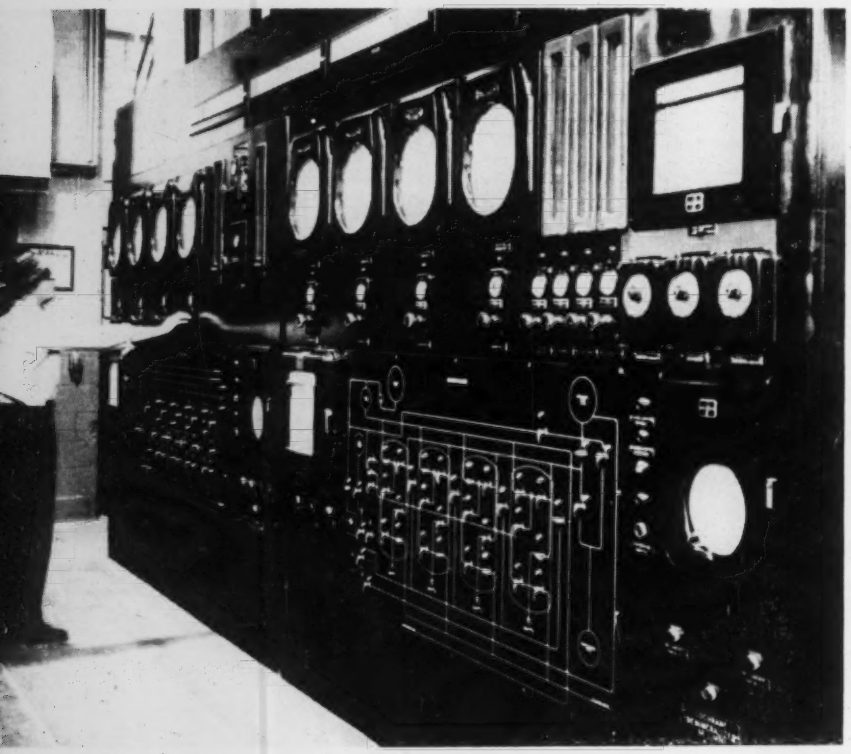


Fig. 3. Demineralizer control panel has anion controls at left, cation panel at right, and schematic flow diagram. A 4-point conductivity meter on each panel shows the operator when the exchanger units are becoming exhausted.

& Tiernan dry-chemical feeders supplying the aluminum-sulphate coagulant and the sludge-blanket weighting agent, and flour clay and liquid-sodium-hydroxide feeding equipments. Based on flow rate, these chemical feeders are actuated by the totalizing meter so that chemical feed is proportional to water inlet flow to the reactors. The time interval and chemical feed rate of the feeding equipment is based on the results of routine daily jar tests made by the operator. There is one limitation of this type of equipment—it is not truly proportioning the chemical feed rate, and timing devices must be set to provide as continuous a flow of chemicals as is possible without the overlapping of impulses from the totalizer control. If our timers are timing out (which means our feeders are running), and the totalizer tells them to start up again, they will completely miss the next succeeding feeding cycle. Therefore, the maximum feeding time allowable is approximately 50 percent of flow time.

Secondly, the totalizer controls the flush back and blow down of the sludge from the concentrator zone in the reactors. Four secondary controllers control flush back and blow down: (1) There is frequency control, consisting of a counter which can be set to the desired number of totalizer impulses which are bypassed between blow-down cycles. (2) As the counter counts off the preset number of totalizer impulses, the flush-back timer opens a valve which flushes back the blow-down header for the preset amount of time; as it times out it automatically shuts the flush-back valve and starts the third control, a blow-down timer. (3) This timer opens a blow-down valve which allows the excess accumulated sludge to be blown down from the reactor concentrator zone. (4) The fourth control used in this cycle is the blow-down valve positioners.

A flowmeter measures the flow of clarified water to the tin mill. It is located between the first- and second-stage neutralizer pH meters on the panelboard.

The water level in the reactors is controlled automatically by an altitude gage actuating a pneumatically-controlled proportioning-water inlet valve, upstream of the mixing divider tank.

The next control of interest is a butterfly-valve bypass pressure-regulating device downstream of the filter booster pumps, which provides the filters and demineralized section with a constant inlet pressure of 50 psi. This control is of extreme importance in minimizing rapid changes in downflow rate of water through the resin beds. Resin beds are light in density, and their sensitivity to flow-rate changes can result in premature break-through or ion leakages; premature break-through will result in excessive regeneration. It has been found impractical to back-wash a resin unit once the resin bed has been disturbed by rapid changes in down-flow rates.

Fig. 3 shows cation and anion panelboards. Each panel contains all the pneumatic three-way valve switches—closed, open, and automatic positions for operating the rubber-lined diaphragm valves (which are springless type and have 40-psi constant applied air pressure to close and 50-psi applied pressure to operate them). These switches are mounted on a schematic flow diagram of the plant, and have a numbered light above them to show the position of its corresponding valve which, when moved from its closed position, actuates a micro switch to operate the light. All valves are numbered and are equipped with manual shut-off jacks. Flowmeters record and integrate the flow of water to each cation, and water from each anion, exchanger. These meters are important in dividing the load on exchangers, and for keeping a record of flow between regenerations.

A four-point conductivity meter on each panel records the conductivity of the effluent from each of the exchangers. These are equipped with relays to sound an alarm when the conductivity exceeds a preset point, and guide the operator in his operation of the plant because they show when a unit is becoming exhausted.

A Needed Instrument

To date, we do not have a good instrument to detect when a cation unit is bad. Conductivity of the cation effluent will vary with the free mineral acidity, which in turn varies with the total dissolved solids in the raw water. Considerable savings could be made on all automatic plants where now the cation exchangers are taken off the line automatically on the basis of gallons of water through the unit. To protect against leakage with this practice, these plants are now operating on an average between maximum and minimum T.D.S. between testing periods.

The manual-operated pneumatic loading stations on these panels are used for positioning the inlet valve to the cation exchangers thereby forcing the units to share the load. The same is accomplished on the anion exchangers by positioning the valve on the effluent line.

The three indicating flowmeters on the right of the cation water flowmeters are used to indicate flow of reclaimed acid, back wash, and rinse rate. The anion panelboard has two of these meters for indicating soda-ash and back-wash rate of flow.

On the lower right-hand side of Fig. 3 is the cycle controller; to the left of each panel is the selector switches and start button for these instruments.

On the extreme right of the cation panel is the regenerant acid strength recorder; below are the timers for the cycle controller.

Regeneration

As shown in Fig. 1, you can exchange or absorb only that amount of calcium, magnesium, and sodium for which you have H ions on the resin. Sodium is the first cation to leak through, and the unit must be taken off the line and be regenerated when leakage reaches a set amount.

What is regeneration?

Regeneration is the replacement of the absorbed calcium, magnesium, and sodium ions on the resin with hydrogen ions. Our plant uses sulphuric acid for a source of hydrogen ions.

Sodium is the first cation to leak through as the resin bed approaches exhaustion. Routine flame-photometer tests indicate when a unit needs regeneration. To regenerate a unit that is in service the operator makes certain all pneumatic three-way switches are on automatic. The selector switch is turned to the unit number to be regenerated, and the cycle-controller start-button is depressed. The time disc on the controller starts moving and causes the inlet and outlet valves to the exchanger to close. It next opens the proper valves to back wash the unit at 384 gpm for 10 minutes. This is necessary to loosen the resin bed. At the end of this period the valves are repositioned so that reclaimed acid can be introduced to the top distribution manifold and pass down through the resin bed to the outlet line, which discharges waste to the equalizer tank. When valves are in position a low-pressure switch starts the reclaimed-acid pump.

Flow of reclaimed acid is controlled at 200 to 300 gpm, depending on calcium ratio to total cations. When a low-level probe in reclaimed-acid tank is uncovered, the reclaimed-acid pump stops and the suction and discharge valves on pump are closed. The cycle controller is automatically started again and it puts the gradient acid regeneration equipment in service by opening the proper valves and regulating reactor effluent to the acid mixing chamber at a fairly constant rate of 200 gpm, which is varied slightly in accordance with conductivity measurements on the diluted acid.

Flow of concentrated acid is controlled by a throttling valve with a positioner. The acid is measured and integrated and the concentrated acid system is shut down after a pre-set flow. The water valve to the mixing chamber is allowed to remain open for a pre-set period to allow the 8% acid to clear the resin bed at a constant flow of 200 gpm. This slow rinse portion of the cycle also serves to flush out the acid system. All on-off control valves in contact with concentrated acid are glass lined.

At the beginning of the fresh-acid regeneration cycle a timer permits the valve to the neutralization system to remain open long enough to permit all of the back wash water to be discharged. Following the time period (based on capacity of the units and flow of acid solution) the valve to the reclaimed acid system is opened.

Followed the regeneration the unit is given a fast rinse at the rate of 530 gpm. During this step a high-level probe in the acid reclaiming tank closes the valve to the tank and opens the valve to the neutralization system. When lights on the panelboard indicate all cycles completed, and the operator has found the sodium leakage reduced to a satisfactory point, he can depress a reset button and the unit is automatically returned to service.

The resin is protected against excessive acid concentrations by a high-conductivity cut-off relay (on the acid percent recorder) and a differential-pressure switch (on the dilution water to the mixing chamber) that measures a preset drop across an orifice equal to 200 gpm. If either of the above function the fresh acid system will be shut down and must be reset manually.

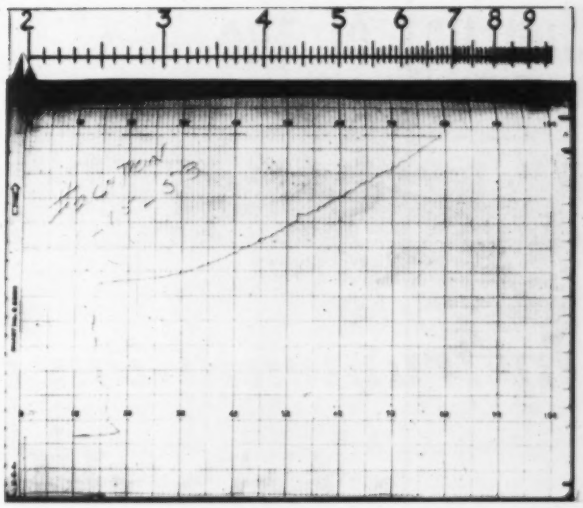


Fig. 4. Percent-acid chart during a cation regeneration cycle.

When all instruments and controllers are functioning properly, a cation regeneration cycle will make a percent-acid chart as shown in Fig. 4.

As the anion resin becomes progressively saturated with chlorides and sulphates the CO_2 is pushed closer to the outlet of the exchanger. When this leakage reaches a point where the conductivity goes above 30 micromhos the unit is considered exhausted. It must be regenerated by replacing the chloride and sulphate ions with hydroxyl ions.

Regeneration of an anion unit is similar to that of a cation unit.

Waste Treatment

All waste water and liquors from the plant are collected in the equalizer tank, which overflows into the first-stage neutralizer tank, where lime slurry is added to maintain a pH of 7.0. A continuous sample of water from the first-stage neutralizer tank is passed through a conductivity cell of the pH recorder controller, which operates a motor valve on the lime slurry system to correct for variations of pH. As a positive check on the neutralization a conductivity recorder constantly measures the pH of the second-stage neutralized effluent.

Air Supply

Clean, dry compressed air for the successful operation of the 71 pneumatic three-way switches, 86 solenoids, 27 diaphragm-operated three-way valves, and the 2 cycle-controllers is obtained by passing plant air through two mechanical water-cooled filters, and then one of two silica-jel dehydrators. One dehydrator is in service while the other is being activated.

Without modern instruments and controllers, a plant of this type could not be operated safely, economically and reliably. However, the instrument field can improve our practice by developing the two following applications: (1) a method of proportioning dry chemical feed more accurately with water flow, and (2) a method of automatically detecting when a cation has been exhausted to a point where sodium leakage is objectionable.

Journal of the S C M A . . .

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Instrumentation of a GASOLINE PLANT

Important factors in the instrumentationof a natural-gasoline plant include (1) control of compressors, (2) temperature control system, (3) liquid-level control, (4) pressure and flow control, and (5) emergency safety instrumentation. The process, instrumentation, and operational factors are discussed.

BLAIR J. WILLARD
The Texas Company

AUTOMATIC measurement and control of process variables and the installation of automatic safety devices is desirable in any plant process, particularly in natural-gasoline plants. Adequate instrumentation means more efficient and safer operation with a minimum of operating personnel.

In order to better understand the instrument requirements of a gasoline plant, a brief description of the plant process should be given.

Gasoline Plant Process

The Texas Company completed its Honor Rancho Gasoline Plant in the Spring of 1954. This plant, which is located on the Los Angeles County's Wayside Honor Rancho, is presently treating approximately 11,000 MCF of wet gas daily.

Wet gas from the field is compressed in the plant from about 20 psi to 350 psi. This gas then enters the absorber where lean absorption oil absorbs some methane and ethane with the propane and heavier components of the wet gas. The dry gas leaving the top of the absorber is cooled and distributed through the dry-gas manifold as field fuel, sales, and injection compressor intake for field injection.

Fat oil (containing absorbed components of the wet gas) leaves the bottom of the absorber and enters the first-stage flash tank where a reduction in pressure causes some of the methane and ethane to escape from the oil. These vapors are recycled by sending them to the intermediate stage of compression. Further flashing of the fat oil is accomplished through heating in the lean-oil—fat-oil heat exchangers and subjection to successive reductions in pressure in the second- and third-stage flash tanks.

From the third-stage flash tank, the fat oil flows to the direct-fired heater (Fig. 1) where the oil is raised in temperature from approximately 300 to 500°F. This hot fat oil next enters the stripping still as feed. Steam admitted in the lower part of the still column strips the oil of its absorbed hydrocarbons. These hydrocarbons leave the top of the still and are condensed and collected in the still accumulator. From the accumulator, this raw gasoline stream is split so that a portion is pumped back to the still as reflux and the remainder is used for the depropanizer feed.

The propane product is removed from a tray draw-off near the top of the depropanizer column. After cooling, the propane is sent to storage. Overhead vapors from the depropanizer are condensed and used for column reflux. Depropanizer bottoms containing isobutane and heavier fractions are used as feed to the stabilizer column.

Overhead from the stabilizer is cooled and condensed to form a 50-psi vapor pressure butane product. Part of this stream is used as column reflux and the rest goes to butane storage. Stabilizer bottoms are cooled and sent to storage as a 16-psi Reid vapor pressure gasoline product.

The lean oil, which is stripped oil from the bottom of the still, serves as a heating medium for the process, as shown in Fig. 1. Steam supplied to the still is generated by passing hot lean oil through a number of heat exchangers which comprise the steam generator. Reboiler heat for the depropanizer and stabilizer is also furnished by this lean-oil stream. Further use of the lean-oil heat is made by heating the fat oil in heat exchangers.

All reciprocating pumps in the process are driven by dry gas. The exhaust gas from these pumps is then used for plant fuel.

October Meeting: *Thursday, the 20th, Rio Hondo Country Club, Downey, Calif.*

Feature: *John A. Haeber, Shell Oil Co., will present a talk entitled, "Trap Farm Instrumentation."*

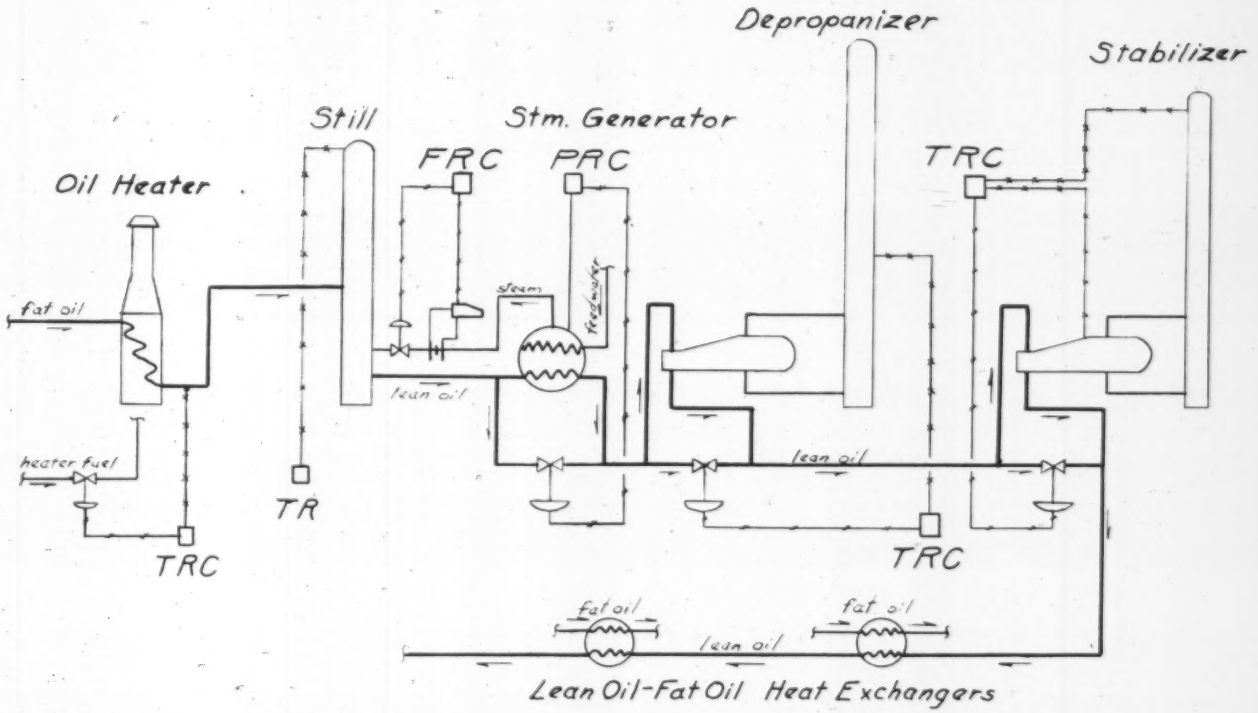

Fig. 1. Basic temperature instrumentation system. Fat oil (from the 3rd-stage flash tank) is first heated to 300-500° F, and then stripped of absorbed hydrocarbons in the still. The hydrocarbons (raw gasoline) are sent to the depropanizer, where propane products are removed from the top; isobutane from the bottom is fed to stabilizer. Lean oil from still bottom is heating medium for the process.

Control of Compressor Load

Control of load on the gas compressors (which compress the wet gas from the field) is accomplished by automatically controlling the flow of gas to the compressor intake. A butterfly valve in the intake line controls this flow. Any variance in line pressure downstream of the valve operates a pilot which allows a change in instrument gas pressure on the valve diaphragm to position the vane.

The arrangement used to control the load on the injection compressor consists of a diaphragm-motor valve operated by a double pilot. One pilot is actuated by the upstream pressure and is normally closed, whereas the other pilot is actuated by the downstream pressure and is normally open. In effect, this system is a combination reducing- and back-pressure regulator which prevents overloading the compressor and also safeguards against the loss of plant pressure upstream of the control valve.

Pressure Control

Pressure is maintained at the desired value in process vessels through use of pilot-operated diaphragm-motor valves. The valve is installed in the vent line from the vessel and is positioned by a pilot actuated by the vessel pressure.

Steam pressure in the steam generator is regulated by a pressure recording-controller utilizing two-mode control. The controller pressure element is connected to the steam drum so that an increase in steam pressure causes an increase in controller output. A control valve on the hot-lean-oil stream to the steam generator is positioned to regulate the flow of oil by-passing the steam generator.

Flow Control

Flow recording-controllers utilizing two-mode control are used to regulate flow of the various process streams. In some instances the controller positions a diaphragm-motor valve to directly vary the flow. Where liquids are pumped by reciprocating pumps, the pump speed is varied. A change in flow results in a change in controller output which repositions a diaphragm-motor valve on the pump-driving gas line.

Temperature Control

Temperature control of fat oil from the direct-fired heater depends on a temperature recording-controller employing three-mode control (bottom left of Fig. 1). To minimize dead time, or controller lag, the instrument is located close to the heater-fuel control valve. The temperature bulb is installed in the oil line downstream of the heater. Controller output operates a valve positioner which positions the control valve. An adjustable travel stop on the control valve prevents complete valve closure in event of excessive temperature deviation above the controller set-point.

Derivative action is used for this control because of the relatively large process lag in the heater system. Through use of derivative action, a narrower proportional band and a faster reset rate can be used to give a quicker recovery with minimum cycling of the controlled variable.

Fig. 1 illustrates the importance of maintaining close control of oil temperature from the heater. This temperature determines the amount of heat available for steam generation and fractionation. For example, if the oil temperature is too high, it is possible that controller action could not by-pass sufficient oil around the steam generator and fractionating-column reboilers to restore the normal heat input to the process. Then the process would become dependent upon manual control until the oil temperature

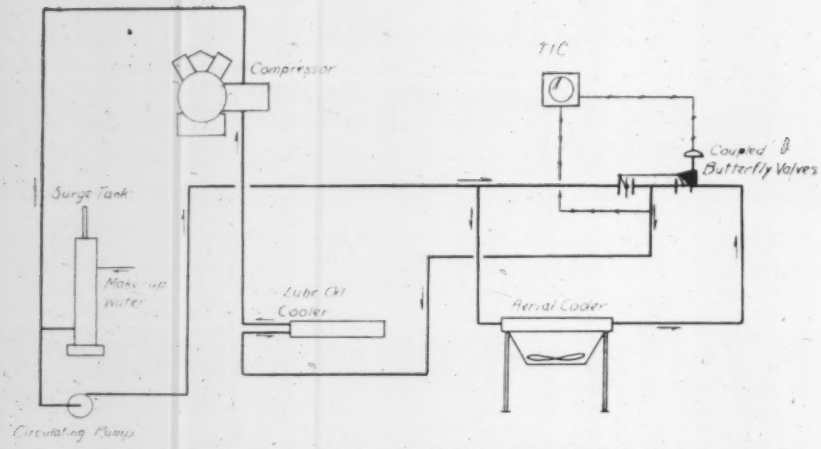

Fig. 2. Control of temperature of compressor lube oil and cylinder-jacket water. Temperature bulb is in line to lube-oil cooler. Controller causes one butterfly valve to open, other to close, bypassing the aerial cooler.

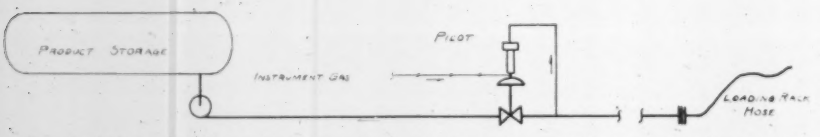

Fig. 3. Safety shutoff on loading rack. Break in loading-rack hose would decrease line pressure, causing pilot to close diaphragm valve controlling gas flow to loading rack.

returns to normal. Derivative action in the direct-fired heater controller prevents this from occurring, and allows a faster return of the oil temperature to the set point when load changes occur.

The *still column temperature* is maintained by manually controlling the amount of reflux pumped to the column. As the still temperature is subject to only rare fluctuations, the use of a temperature controller was not considered justified at this point.

As shown in Fig. 1., *temperature control of the depropanizer column* is maintained by regulating the flow of hot lean oil through the reboiler. A temperature recording-controller using two-mode control regulates the temperature on a tray below the feed tray. By positioning a diaphragm-motor valve, oil is made to either flow through or by-pass the reboiler.

Temperature control of the stabilizer differs from that of the depropanizer only in that the temperature bulb is located in the reboiler. A temperature recorder records the top temperature of the stabilizer so that an indication is given of depropanizer-column performance. A drop in this top temperature would indicate carryover of propane from the depropanizer with resulting contamination of the butane product.

The method for *controlling the compressor lube oil and cylinder-jacket cooling-water temperature* is shown in Fig. 2. The cooling water is pumped from the cylinder jackets to the aerial cooler and then to the lube-oil coolers. A temperature bulb in the line to the oil coolers senses changes in temperature and causes a temperature indicating-controller to increase or decrease its output to a diaphragm-operated butterfly valve. This valve is linked to a second butterfly valve in such a way that closure of one valve occurs as the other valve opens. This system acts as a by-pass for the water around the aerial cooler and thus controls the cooling-water temperature.

The injection compressor discharges at a pressure of about 2000 psi. As there is a possibility of hydrate formation at this pressure, the temperature of the discharge gas is regulated so that the temperature of the gas at the point of injection will not be lower than 100° F. This is done by the automatic adjustment of louvres on the aerial cooler which cools the compressor discharge. A temperature bulb in the discharge gas lines from the outlet of the cooler causes the action of a pneumatically operated positioner which either opens or closes the louvres to vary the amount of air passing through the cooling coils.

Liquid-level Control

Liquid-level control in this plant is extensive; only a minimum attention is required by the plant operator. Level controllers used are of two types. For the dumping of liquids from the compressor interstage scrubbers, a floatless controller is used; this type depends on the static head of liquid in the vessel to operate a pilot which in turn operates a diaphragm motor valve.

The other type, which is used on the process vessels, is a float-operated, pneumatic controller. These controllers employ the conventional nozzle-and-flapper action to provide operation of the control valve. With proportional band settings, they are widely used on vessels where liquid surging is encountered. They are excellent for interface service and find extensive use on oil-water separators.

The liquid-level controllers on the fat-oil surge tanks are a good example of the application of the float-type controller. The controllers are reverse acting. The control valve is located on the vent line from the flash tank. As the oil level rises, the decrease in controller pressure closes the control valve which causes an increase in vessel pressure. This increase in pressure forces oil out of the vessel until normal level is restored.

Emergency Instrumentation

Owing to the potentially hazardous nature of gasoline-plant operation, use of emergency instrumentation is of extreme importance.

At points in the process where an excessive increase or decrease in liquid level would either cause a serious upset in plant operation or perhaps damage equipment, explosion-proof electrical alarms and shut-down switches have been installed. The level alarm is activated by a float which operates both visual and audible alarms. Similarly, the level shut-down instruments are float-operated switches which operate relays which ground the compressor-engine magnetos.

To provide for the possibility of a rupture in the hoses which are used to ship butane and propane into tank trucks at the loading rack, a system shown in Fig. 3 is used. A pilot-operated diaphragm-motor valve is located on the loading line. Pressure on the downstream side of the valve operates the pilot and allows instrument gas to hold the valve open. In event of a hose break or any other accident which would cause an abnormal pressure drop downstream of the control valve, the pilot would shut off and the control valve would close. A means of manually holding the control valve open is provided so that loading can be started. The shipping pumps are equipped with pressure switches on the discharge side so that any excessive discharge pressure will shut off the pump motors.

In addition to the usual emergency controls on the compressor engines

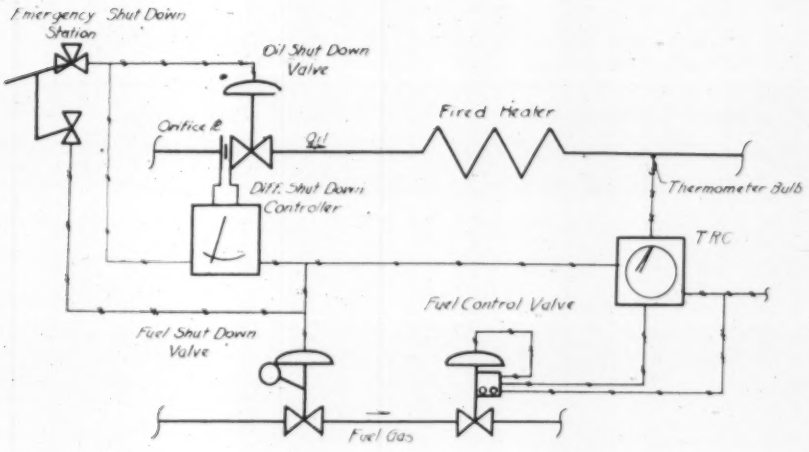

Fig. 4. Emergency instrumentation of the direct-fired heater. Fuel is controlled normally by temperature of oil output from heater. Emergency shutoff is provided by weight-loaded diaphragm valve. Decrease in oil flow to the heater, or excessive temperature of oil, will operate differential controller, which operates weight-loaded shutoff valve.

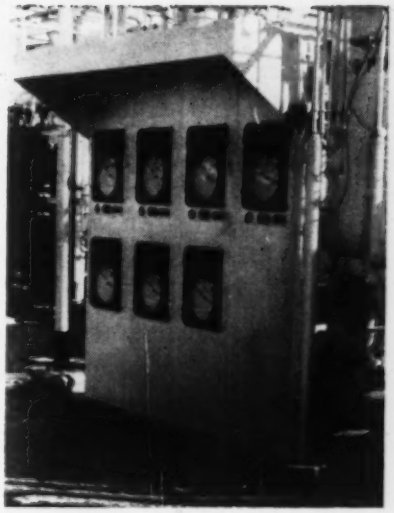

Fig. 5. Typical control panel shows arrangement of instruments. All controllers have 4-way transfer switches for servicing, automatic, or manual control.

(such as low-oil-pressure shut down and overspeed trips) an electrically operated temperature switch is installed in the lube-oil line to the engine. Any variance in temperature outside the set range of this switch will ground the engine magnetos.

At convenient locations throughout the plant, a number of manual shut-down stations are installed. In an emergency, the plant operator can shut off all compressors by pressing a switch which operates relays to ground the compressor-engine magnetos.

Fired-heater Emergency Controls

Perhaps the most important emergency instrumentation in the plant is that provided for the direct-fired heater (Fig. 4). Both automatic and manual controls are used.

A pneumatically-operated differential limit controller is connected to a pair of flange taps across an orifice plate and is set so that a decrease in differential below a predetermined value will result in zero output from the instrument. Instrument output is connected to a weight-loaded diaphragm valve on the heater fuel line. Therefore, a decrease in oil flow through the heater will shut off the heater fuel. This prevents the possibility of damaging heater tubes in event of low oil flow.

In addition, the temperature recording-controller for the heater is equipped with a high-temperature-limit operator. If the temperature of oil from the heater rises to a dangerous level, the limit operator will unload instrument gas pressure from the weight-loaded diaphragm valve on the fuel line and cause the valve to trip shut. A pressure switch on the instrument gas line to this valve operates visual and audible signals whenever the valve diaphragm is unloaded. This immediately informs the plant operator of a heater shut down. Manual resetting of the valve is necessary before the heater can be refired.

The heater can be shut down manually at some distance away in event of fire or other emergency by means of a manual shut-down station. This consists of two bleed-off valves with connecting handles. The operation of one valve will cause the operation of the other. These valves bleed gas pressure from the diaphragm of a motor valve on the oil line to the heater, and also bleed gas from the input and output of the differential limit controller. This causes the oil valve and gas valve to close simultaneously to completely shut down the heater. These valves are for emergency use only and are not intended to be used for normal shut downs.

All emergency instruments are checked at frequent intervals to insure their proper functioning at all times.

Instrument Gas

Plant dry gas is used for all pneumatic instruments. This instrument gas is passed through a completely automatic dehydrator which consists primarily of two containers of silica gel. By means of a multicam timer driven by a synchronous electric motor, each container undergoes a cycle of dehydrating and reactivating every 12 hours. After dehydration, the gas pressure is reduced from plant pressure to 40 psi. Each instrument requiring gas is equipped with a filter and a pressure regulator, which maintains a supply pressure of 18 psi to the instrument.

Arrangement of Instruments

With few exceptions, all recorders and recording-controllers are panel mounted on three separate panels located in the main process area. These instruments are grouped according to their relation to each other in the process. Fig. 5 shows a typical panel. All controllers are equipped with four-position transfer switches. These switches facilitate servicing and testing of the instruments and allow manual control in event of abnormal process upsets.

At the wet- and dry-gas manifolds there are six lines, each of which has a mercury-type flowmeter. The flowmeters are individually mounted in line on pipe stanchions and are housed in a three-sided shelter of galvanized sheet metal. This convenient grouping of meters aids in the quick changing of charts and the checking of the instruments.

Other local-mounted flowmeters are installed on pipe stanchions close to their respective meter runs. These are protected with individual meter boxes. On gas service where entrained liquids and condensation occur, the flowmeter lines are equipped with drip pots which are drained periodically. All lines slope toward the orifice fitting so that there is less possibility of trapping liquids in the lines.

All plant instruments are checked periodically and a regular program of preventive maintenance is followed to insure continuous, accurate, and dependable operation.

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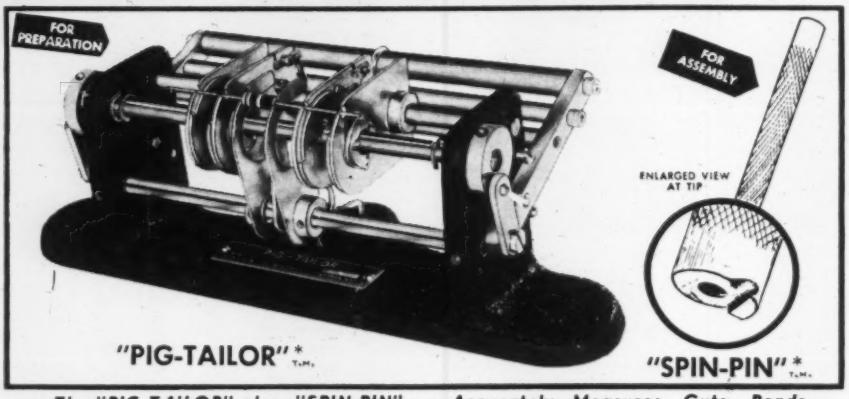

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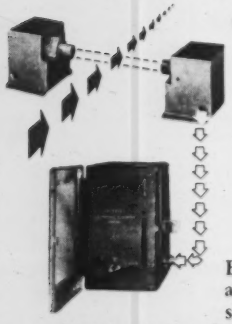

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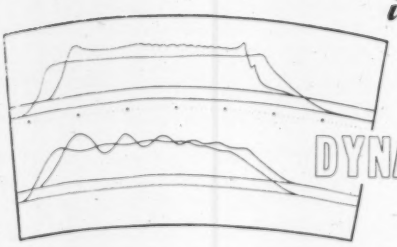

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See Page 1567 for Answers

All Questions are based on editorial matter in this issue.

Question 1

Routh's criterion is a method for examining controlled-system stability. The method is applied only to the

(a) controller constants
(b) system parameters
(c) coefficients of the system equation
(d) transfer functions describing the system

Question 2

The heat flow factor of a combustion gas is:

(a) a term representing heat content for use with combustion-air demand
(b) the BTU content over square root of specific gravity
(c) the Nov Formula, or Wobbe Index
(d) all the above

Question 3

In combustion work, a K meter is a

(a) specific gravity meter
(b) flow meter
(c) heat flow factor meter
(d) BTU meter

Question 4

The most commonly used vacuum gage for pressures lower than 10^{-4} mm Hg is the

(a) triode ionization gage
(b) manometer
(c) thermocouple gage
(d) Pirani gage

Question 5

In the triode ionization gage the pressure is measured as a function of

(a) grid electron current
(b) plate ion current
(c) filament temperature
(d) plate temperature

Question 6

Which of the following is a unit of pressure?

(a) Atmosphere
(b) Barye
(c) Tor
(d) All the above

Question 7

A pressure of 1 micron is equivalent to

(a) 10^{-6} mm Hg
(b) 10^{-3} mm Hg
(c) 1 mm Hg
(d) 10 mm Hg

Question 8

Which of the following statements about a triode ionization gage is NOT true?

(a) Plate voltage is negative with respect to the grid and filament.
(b) Grid voltage is positive with respect to the filament.
(c) Grid collects the positive ions.
(d) Tube is operated in temperature-limited-emission condition.

Question 9

The advantage of trapezoidal integration over rectangular integration in a digital differential analyzer is

(a) simpler equipment
(b) more rapid operation
(c) reduced error
(d) all the above

Question 10

The term "iteration" in a digital differential analyzer refers to

(a) taking data from the drum
(b) integrating and summing the data
(c) placing the data back on the drum
(d) all the above

Question 11

Which of the following statements about iteration in the D-12 DDA is true?

(a) The iteration process requires only one integrator.
(b) All 60 positions on the drum are processed on each drum revolution.
(c) Data is typed out automatically on each iteration.
(d) A curve is drawn on each iteration.

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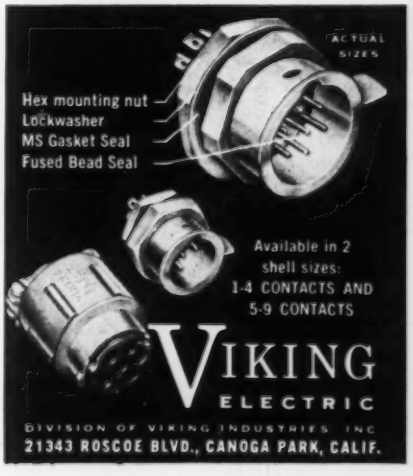


For more information circle **124** on inquiry card.

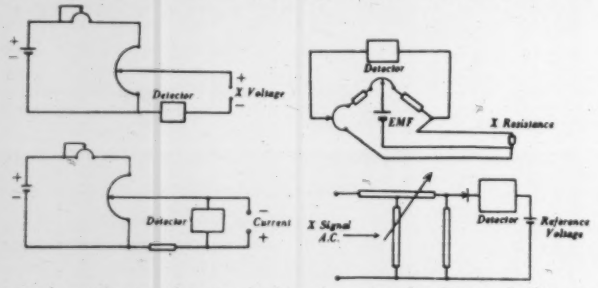
Briefs . . .

INSTRUMENTS and AUTOMATION

For this literature use postage-free order card on page 1569

Speedomax Recorders

Speedomax recorders provide over 2300 variations of measuring circuit, each developed for application to certain types of measuring problems. All are null-balance circuits. The unknown quantity to be measured is bal-



anced against a known value (or standard), and the resulting value is automatically indicated or recorded by the instrument. Available circuit types include:

Voltage Balance. Input voltage to be measured is balanced against a known calibrated voltage obtained from a potentiometer slidewire. Used for measuring voltage, as such, or the output of various primary elements and transducers which produce a voltage—thermocouples, pH electrodes, current shunts, etc.

Current Balance. Input current to be measured is balanced against a calibrated current obtained from a recorder slidewire. Used for measuring current, as such, or the output of primary elements which produce direct current—photoelectric cells, etc.

Resistance Balance. Unknown resistance to be measured is balanced against known standard resistances in a bridge circuit. Used for measuring change of resistance in primary elements—Thermohm resistance thermometers, conductivity cells, etc.

Power Level. Power input to be measured is continuously attenuated to maintain equality with a reference source of power. Resulting insertion loss of an automatically-balanced slidewire attenuator gives the level (in decibels) of an unknown power referred to approximately 0.2 microwatt.

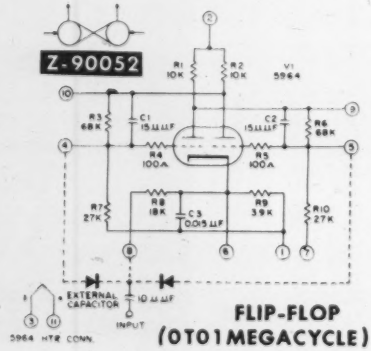
Of these four null balance circuits, voltage balance is the most versatile as it lends itself to more variations and applications than the others. (*From new* 48-*page Technical Publication No.* 46, *Leeds & Northrup,* 4907 *Stenton Ave., Phila.* 44, *Pa.*)

For this literature circle **501** on inquiry card.

Plug-in Circuits

The design engineer gains a new freedom as a "block diagram man." He now uses plug-in units as building blocks, with design time reduced to a minimum. Plug-in units can be used as stock items.

Breadboard and prototype equipment is given a professional appearance with the use of plug-in units; ensuing production runs are easily made with plug-ins, with no necessity of wiring, layout, or other changes from prototype.



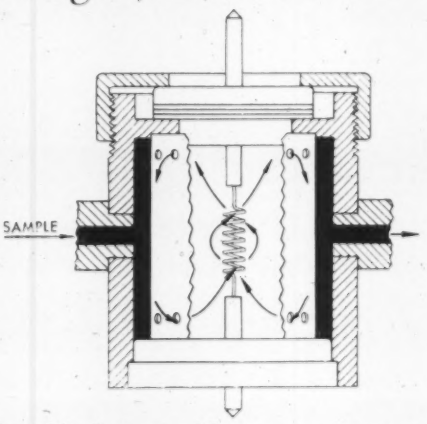
FLIP-FLOP (0TO1MEGACYCLE)

Maintenance problems are simplified and "down-time" reduced to a minimum; faulty units can be found easily and new ones plugged in with ease of plugging in vacuum tubes.

EECO offers completely repairable, low priced units instead of costly "throw-away" type units. Plug-ins can be taken apart without tools and repairs made easily. (*From new* 32-*page Catalog* 81554, *containing specifications on* 29 *amplifiers, diodes, flip-flops, gates, one-shots, phantastrons, etc., and typical applications. EECO Production Co.,* 827 *S. Vermont Ave., Los Angeles* 5, *Calif.*)

For this literature circle **502** on inquiry card.

Combustible-gas Instruments



M.S.A. Combustible Gas Instruments are an effective, precise and dependable means of indicating accumulations of explosive or toxic flammable gases and vapors in the air. The instruments . . . are basically simple in operating principle. They are adaptable for use with any gas or vapor whose explosive range, and molecular weight are known, and their applications extend to all industries where combustible fluids are employed.

The concentration of combustibles in air is determined by (1) drawing a sample of the air to be tested over a wire heated sufficiently to burn the gases on its surface and (2) measuring the change in the electrical resistance of the wire resulting from the additional heat of this combustion. The change in resistance is proportional to the gas concentration up to and including the lower explosive limit.

When the temperature of any metal (excepting a few special alloys) increases, its electrical resistance undergoes a corresponding rise. A change in the temperature of a wire can be indicated by measuring the resulting change in its electrical resistance (by Wheatstone bridge).

In practice, a coiled detector filament of pure platinum wire is heated to a definite and constant temperature by passage of a constant electric current. When air samples containing flammable gases are drawn over the filament, a surface combustion occurs. This raises the temperature of the platinum wire in proportion to the amount of flammable gases in the sample. (*From new* 20-*page brochure* 0703-3, *Mine Safety Appliances Co.,* 201 *N. Braddock Ave., Pittsburgh* 8, *Pa.*)

For this literature circle **503** on inquiry card.

Synchronized Streak Camera

Transient events, such as explosive, flash-tube, shock-wave, and spark-discharge phenomena are suitable subjects for study with the Beckman & Whitley Model 168

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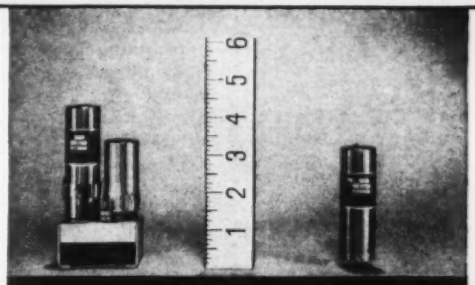

PRECISION FORK UNIT
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Type 50
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Type R 50
± .002% at 15° to 35°C

FREQUENCY STANDARD
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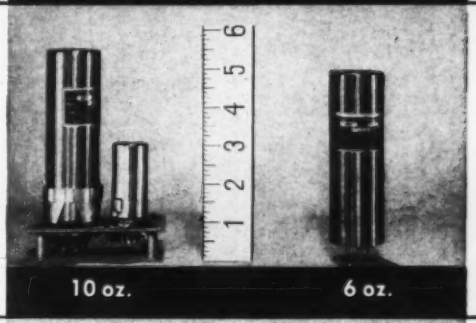
Type 2003 C
± .02% at — 65° to 85°C

Type R 2003 C
± .002% at 15° to 35°C

Type W 2003 C
± .005% at — 65° to 85°C



PRECISION FORK UNIT
200 to 4000 Cycles

Type 2003
± .02% at — 65° to 85°C

Type R 2003
± .002% at 15° to 35°C

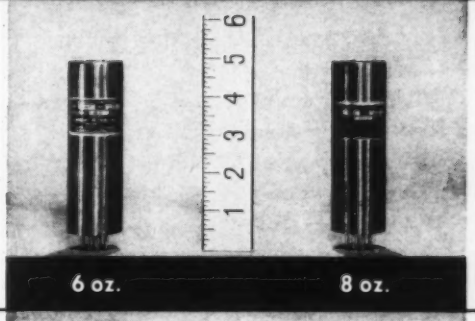
Type W 2003
± .005% at — 65° to 85°C

FREQUENCY STANDARD
200 to 2000 Cycles
Sub-miniature Tube

Type 2007
± .02% at — 65° to 85°C

Type R 2007
± .002% at 15° to 35°C

Type W 2007
± .005% at — 65° to 85°C



FREQUENCY STANDARD
240 to 1000 Cycles
Transistorized

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Type R 2007 T
± .002% at 15° to 35°C

Type W 2007 T
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± .001% at 20° to 30°C

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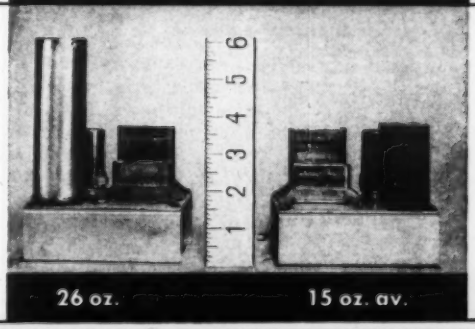

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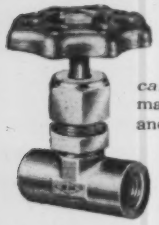

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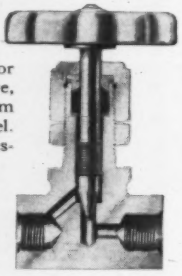

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BRIEFS —CONTINUED

Synchronized Streak Camera. Used to record those events which can be synchronized with the camera mirror angle, this position-vs-time synchronized sweeping-image recorder is of the type sometimes referred to as a smear camera. Events which must occur at random with respect to mirror angle can be recorded only by a continuous-writing streak camera, such as the Model 194.

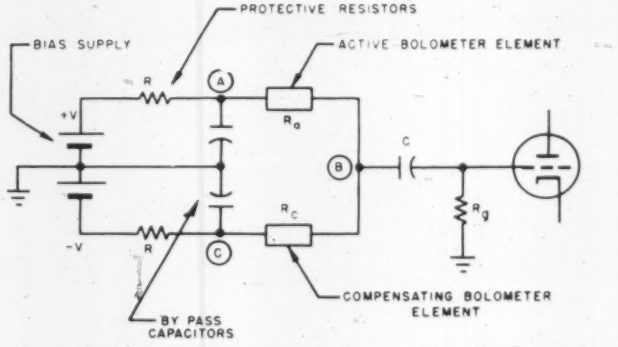
In use, the Model 168 Camera plots on film the progress of an event against rectangular coordinates where the vertical axis represents space and the horizontal axis represents time. This technique is effective not only with self-luminous events, but also schlieren and interferometric effects. At maximum operating speed (50,000 rpm) the standard unit has a sweep rate of 5.46 millimeters per microsecond, and an elapsed time of 44 microseconds for the image to sweep the film. (*From new 4-page brochure, Beckman & Whitley, 985 San Carlos Ave., San Carlos, Calif.*)

For this literature circle **504** on inquiry card.

Thermistor Heat Detector Cells

Servotherm cells are thermistor bolometers constructed of thin flakes of semiconductor material with a high negative temperature coefficient of resistance. The flakes are blackened to achieve absorption of about 80% of the infrared radiation received.

TYPICAL DETECTOR CELL CIRCUIT



A typical assembly consists of an active flake which receives the radiation and a compensating element shielded from the radiation. These are attached to a heat sink which takes part in determining the speed of response and sensitivity.

Temperature variations are detected remotely and accurately without contact with the process . . . temperature variations from ambient to 1000°C are detected . . . bolometer noise is less than twice the Johnson noise and free of microphonics.

Speed of response, even at low sensitivity, is from 0.002 to 0.012 second, depending on model.

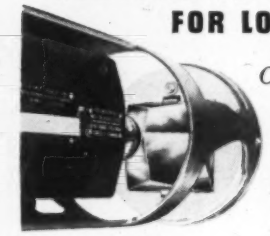
Sensitivity: Energy from a 400°K body blackbody chopped at 15 cps produces a response of 50 to 400 volts/watt (depending on model used)—enough to detect 0.05°C temperature change with simple lens system and amplifier. (*From new 2-page Bulletin TDS-HDC, "Servotherm," Servo Corp. of America, New Hyde Park, N. Y.*)

For this literature circle **505** on inquiry card.

Damping Devices

The most primitive type of dash pot consists of a cylinder closed at the bottom and open at the top; inside the cylinder a loose-fitting piston moves up or down. When the cylinder is partially filled with liquid, it can flow from one side of the piston to the other between the cylinder wall and the piston . . . When the piston moves it meets with a resistance force proportional to the speed with which it

HOW WE SOLVED A PHOTOGRAPHIC PROBLEM FOR LOCKHEED



Creative Glass Engineering like this suggests how Bray Optical can help you

In the picture above, you see a specially designed multi-facet prism-reflector which enables the camera to record four separate images on a single frame. A pretty technical bit of lens design is this reflector—so when Lockheed Aircraft Corporation needed this prism in its research work, the complete job of design and fabrication was turned over to us.

Problems: High-order resolution, calling for critical plane relationship and surface tolerances • Zero distortion under extreme operational conditions • Extreme temperature variations.

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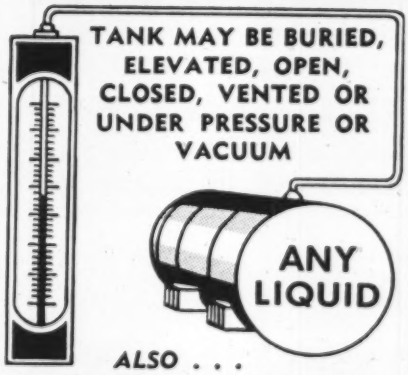

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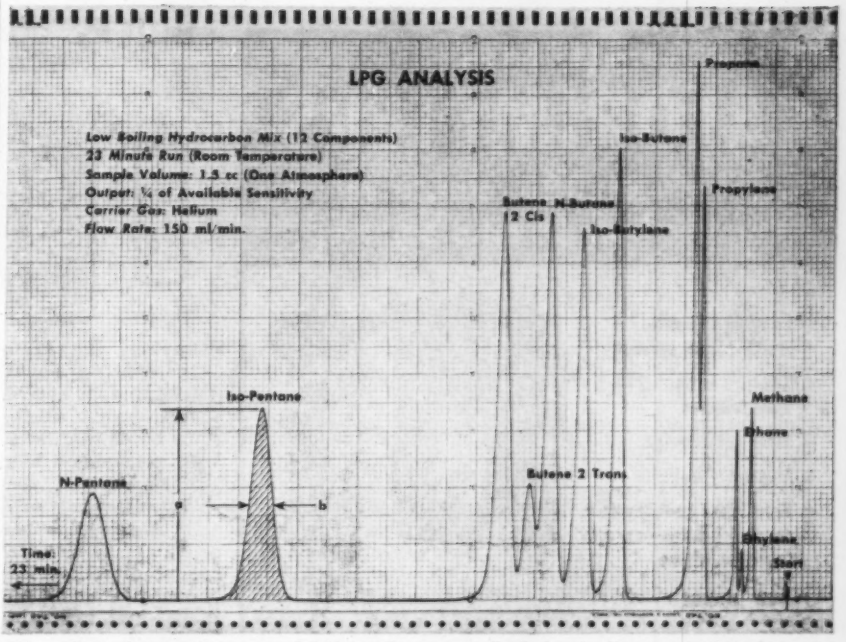


Photo of actual run made on new P-E Vapor Fractometer. To find mole % concentration of a component, analyst simply integrates area under peak by multiplying peak height (a) times half-band width (b).

This quantitative analysis took only 23 minutes on the new P-E Vapor Fractometer that costs only $1,375

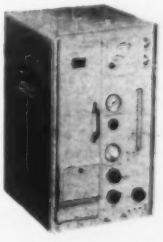
HOW LONG WOULD IT TAKE YOU?

Employing the principles of gas chromatography, P-E's new vapor fractometer is a revolutionary advance in the field of gas and volatile-liquid quantitative analysis. It is fast, precise, uncomplicated to operate, extremely simple in calculation, and above all, many times less expensive than distillation columns, mass spectrometer, or any other instrument, for the purpose.

For qualitative analysis, the instrument gives extremely clean separations—even of components and isomers which cannot be separated by ordinary methods. For trace analysis, high sensitivity permits use of extremely small samples.

Take, for example, the analysis of a synthetic LPG mix shown above. Here 12 components, representing the hydrocarbons most frequently encountered, were clearly separated—a job extremely difficult to accomplish by ordinary vacuum distillation methods. The perfect shape of the recorder bands makes quantitative analysis simple and accurate. Area under each peak is the measure of the mole % concentration of the component. These area relationships are all that is needed for calculation, without preliminary calibration for each individual component.

There is no faster, no simpler, no more inexpensive method in existence today.



This is the Model 154 Vapor Fractometer—price, $1375.00 without recorder. Send for descriptive bulletin.

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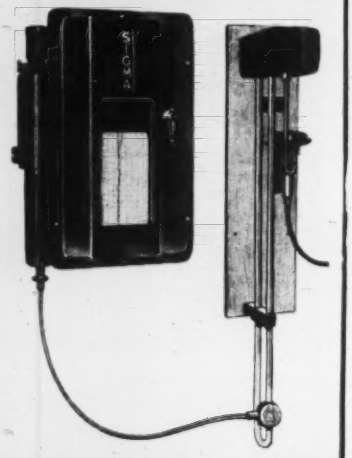

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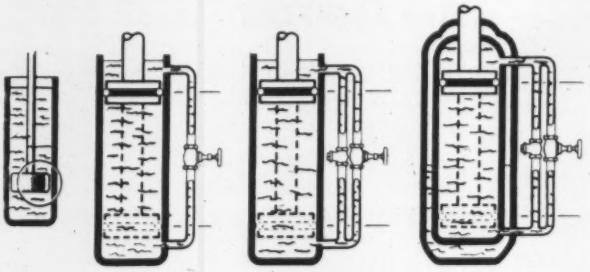

travels . . . Accurate control of resistance force is impossible, although some modification can be made by changing relative diameters and piston of cylinder and piston or viscosity of liquid.

Later modifications employ a cylinder and sealed piston, plus a single bypass pipe for control of resistance force . . . Various types of valves are placed in the bypass pipe to adjust rate of liquid.

A second bypass pipe, with check valve, is sometimes affixed to the dash pot to provide minimum resistance in one direction. This makes it possible for different resistance forces on extension and compression strokes.

Final stage in evolution occurred when the top was closed, and a reservoir added to serve as an expansion chamber. By eliminating atmospheric pressure and by closing the circuit, pressure within the dash pot can be increased and controlled.

The Gabriel direct-acting damping device is a small telescopic tube (in which) all piping and valving has been consolidated within the casing. (*From new 24-page booklet "Damping Devices—Past, Present, Future," The Gabriel Co., 1148 Euclid Ave., Cleveland 15, Ohio.*)

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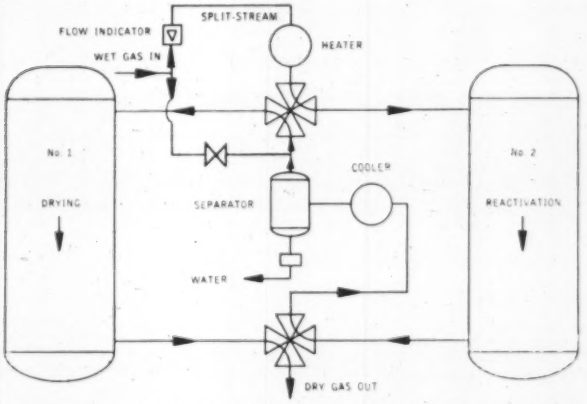
Hydryer with Split-stream Reactivation

In the majority of drying applications more gas is available than needed for reactivation. In such cases only a portion of the entering gas stream is used while the remainder flows directly to the drying vessel. The split-stream is measured, heated and passed through adsorber #2 which is to be reactivated. Adsorbed moisture is vaporized and passed to the cooler. The gas temperature is reduced to its original inlet temperature, thereby condensing the moisture, which is separated and removed. The stream thus enters the second bed at the same conditions as it enters the Hydryer. Moisture is adsorbed in the (left) drying vessel and the gas discharges at the required dew point. (*From new 8-page Bulletin* 16.0.081, *J. F. Pritchard & Co. of Calif.*, 4625 *Roanoke Pkwy., Kansas City* 12, *Mo.*



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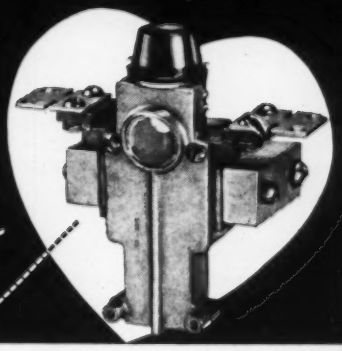

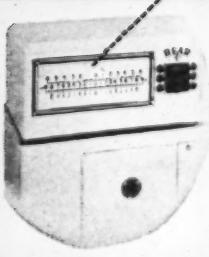

IN THE AUTOMOTIVE FIELD, the Bear Manufacturing Co. of Rock Island, Ill. uses Series 500 G-M Galvanometers in its new remote-reading Electric Wheel Alignment System (left). Whatever your own particular instrument field, you can achieve this same self-contained portability, ruggedness and high sensitivity with G-M Galvanometers. Complete catalog on request.

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G-V thermal sensing relays

G-V Sensing Relays operate contacts when current or voltage to their heaters exceeds or drops below the operating point. They can be selected with a response rate paralleling the action of the equipment. These relays operate quickly on heavy changes but tolerate slight changes until they become dangerous.

Meets military requirements

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- **MAXIMUM LIFE** . . . outlasts other converters by years of continuous operation.

Now a brand new ultra-high-speed reversible data converter . . . DATRAC . . . automatically translates voltages to digital data or reverses the process.

Bulletin just released shows suggested DATRAC applications such as: engine test data translation; reduction of shaft rotation and thermocouple or strain gage information to digital form; precision analog recording and playback; machine tool and chemical process control; and many others. Also includes specifications of five DATRAC converter models. Send for your copy . . . TODAY!

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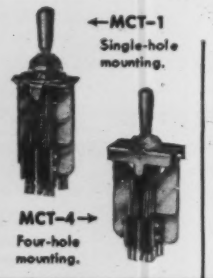
For more information circle **134** on inquiry card.

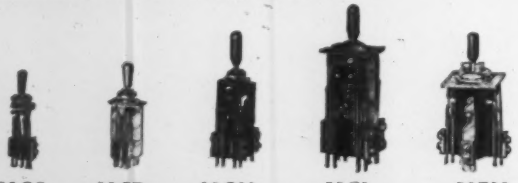


Type MCT Lever Switch

Solid switch frame provides electro-static shield. Variety of lever operations and contact assemblies provide multiple circuit control. Fine silver or palladium silver contacts available.

Write for Bulletin CL-100

All General Control switches feature riveted coin silver or palladium alloy contacts and are individually adjusted and inspected. Switch types are available from 1 to 10 amperes.
Also available are special switches and contact assemblies to customer specifications.



MCS MCT MCM MCL MFM

FOOT, LEVER, PUSH BUTTON and LIMIT SWITCHES
ELECTRONIC and SYNCHRONOUS-MOTOR TIMERS
CUSTOM CONTROL PANELS

GENERAL CONTROL COMPANY
1218 Soldiers Field Road • • Boston 34, Massachusetts

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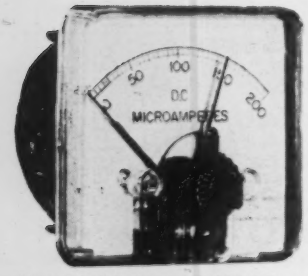
METER-RELAYS

For Sensitive and Accurate Control



Model 261-C Range 0/200 DC Microamperes Price $33.00

RANGES:

0/20 Ua. to 0/50 A.
0/5 Mv. to 0/500 V.

The trip point is adjustable to any point on the scale arc. These meter-relays are sensitive to changes of as little as 1%. One contact is carried on moving pointer. The other is on a semi-fixed pointer. When two pointers meet contacts close and lock. Holding coil is wound directly over moving coil. Reset can be manual or automatic. Spring action in contacts kicks them apart forcefully. Three sizes of clear plastic case models, 2½, 3¾ and 4½ inches (all rectangular). Two ruggedized and sealed models, 2½ and 3½ inches (round metal cases).
Contact arrangements: High Limit Single, Low Limit Single or Double (both high and low). Contact rating is 5 to 25 milliamperes D.C.

Suggested circuits for meter-relays and complete specifications including prices are covered in new 16-page Bulletin G-6, which you can get by writing Assembly Products, Inc., Chesterland 10. Ohio.

For more information circle **136** on inquiry card.

BRIEFS—CONTINUED

Neg'ator Constant-force Spring

The Neg'ator spring (pronounced *Negga'*tor) is an elastic member that exerts a restraining force which does *not* increase as it is extended. By thus upsetting an old

axiom of spring performance, this device opens the door on a whole new field of mechanical design. For example . . . a spring, held in the palm of the hand, which can extend 6 feet or more, exerting an unvarying force . . . a spiral driving spring delivering constant torque from fully wound condition . . . a spring weighing 1.5 lbs, and performing all the functions of a 50-lb counterweight.

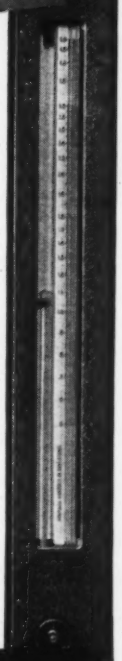
The device resembles a roll of metal tape . . . a highly stressed strip of spring material. When coiling or uncoiling the spring develops its resisting force only in the portion of the material where the straightening action is taking place. (*From new 16-page Bulletin* 310N, *Hunter Spring Co., Lansdale, Pa.*)

For this literature circle **508** on inquiry card.

Thermocouple Circuit "Restorer"

Accurate checking of low-resistance electric circuits such as thermocouple circuits has long been a major problem. The problem is especially critical when the accuracy of a pyrometer is in doubt during a heat-treating or melt-

NEW TYPE II VISCOMETER



Portable or Panel Mounted
TO INDICATE KINEMATIC VISCOSITY

The Type II Viscometer, a new and completely different type of laboratory-field instrument, is the first of its kind ever developed for directly determining *in a matter of minutes* the kinematic viscosity of fuels, oils, weak acids, and other base solutions.

Range of the Type II, which employs a new method based on a flow system of advanced design, is .5 to 5.0 centistokes. This range includes all liquids used in testing aircraft fuel system components. Readability of the instrument is well within 1% of the indicated viscosity at any point on the scale.

- Use it in the laboratory, field, or on new or existing equipment.
- Widest range. Outstanding readability.
- Simple to operate. Readings obtainable in a few minutes.
- Portable or panel-mounted — supplied complete with thermometer, filter, filter cartridge, and AN outlet fittings.

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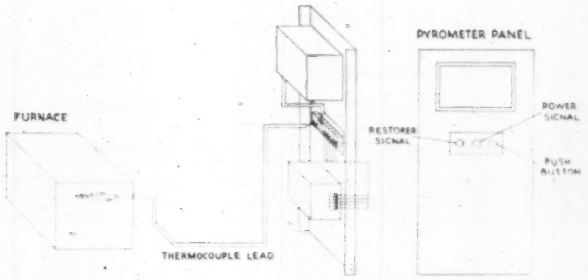

ing operation. When indicated temperature controls a heat, true pyrometer readings are doubly important. For example, a pyrometer may be reading 50 degrees lower than the actual furnace temperature. Although furnace temperature is correct, the control (manual or automatic) raises the temperature 50 degrees. The heat is now 50 degrees too high.

To test a thermocouple circuit, the Peerless "Restorer" is operated (manually or automatically). This first disconnects the pyrometer to prevent its being damaged. The Restorer power supply then sends an impulse—400 volts or less—through the thermocouple circuit. This impulse refuses line breaks or separated thermocouple tips, and restores proper conductivity through high resistance (loose, oily or corroded) connections. It will even temporarily repair certain partially deteriorated thermocouple tips. The Restorer impulse will not affect a correct circuit.

When the Restorer operation stops, the high voltage is removed from the circuit and the pyrometer is reconnected. The new pyrometer readings are accurate because true conductivity of the thermocouple circuit has been restored. The pyrometer now indicates the full thermocouple generated voltage.

The repair accomplished by the Restorer will usually last for hours. (*From new 8-page Form R22, The Peerless Electric Co., 1401 W. Market St., Warren, Ohio.*)

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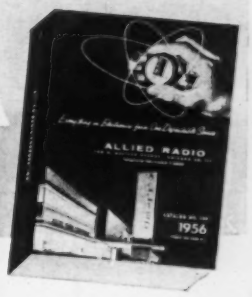

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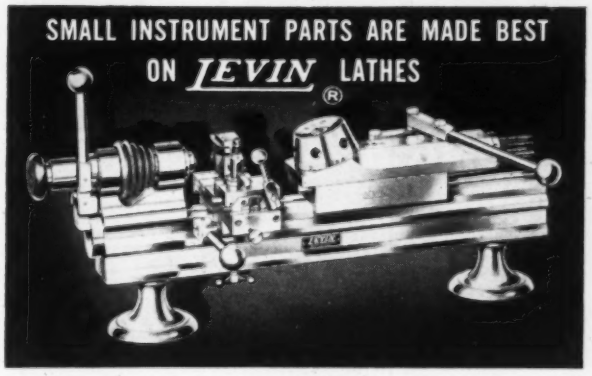
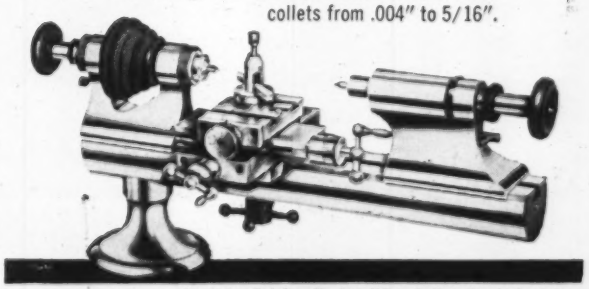


Twenty-three models for all types of work. 4" swing, Bed Length 12" or 18"; over 100 stock sizes of collets from .004" to 5/16".



Send for Catalog M describing Lathes for tool work, second operations; turrets and full line of accessories.

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At Hughes we are conducting fundamental research and development and production engineering in the fields of radar systems, guided missiles, digital and analog computers, microwave tubes, semiconductor products and other activities requiring use of many types of test equipment.

Those with extensive experience in the calibration and maintenance of precision electronic and electromechanical test equipment—with emphasis on measurement of electrical quantities to very close tolerances—will find satisfying outlets for their abilities in this work at Hughes.

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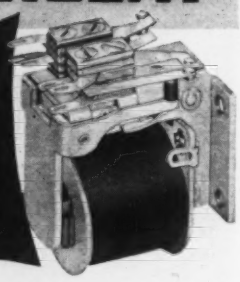
Cool-Running
Ideal for use where hermetic sealing and dust covers are required



TYPE "R"

Withstands Vibration Up to 10G at 5 to 55cps.

•

Shock Resistance 20G, energized 15G, non-energized

COILS: For all standard voltages up to 220 volts, AC. Average coil consumption, 2.5 VA.

CONTACTS: 6PDT up to 5 amps. at average 7.5 VA; 4PDT up to 5 amps. at average 2.5 VA; DPDT up to 10 amps. at average 7.5 VA; fine silver. Other contact materials available.

SIZE: 1½" x 1 11/16" x 2¼", depending on contact combinations.

Available hermetically sealed or with dust covers.

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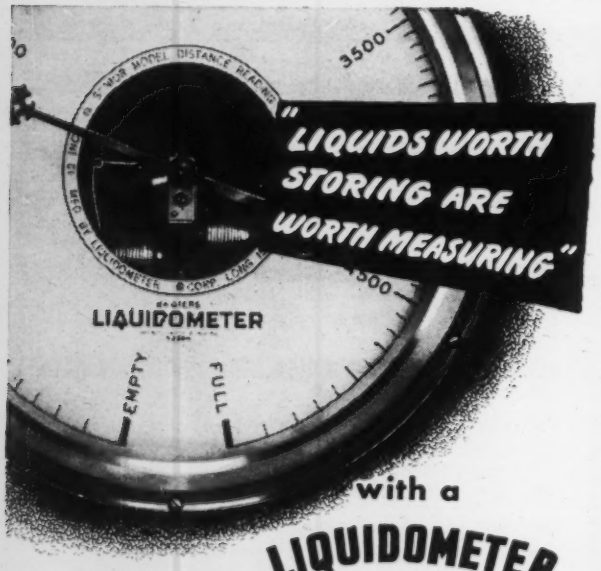

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- 100% AUTOMATIC
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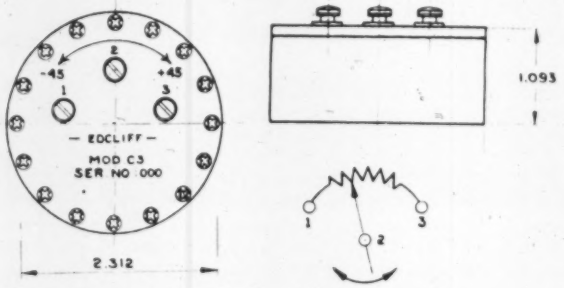
36-27 SKILLMAN AVE., LONG ISLAND CITY, L.I., N.Y.

For more information circle **142** on inquiry card.

Pendulum Indicator

Precision indication of angles in a single axis is the function of the Edcliff Model C-3. The pendulus mass, supported by instrument-type ball bearings, actuates a potentiometer producing an output linear with rotation. Applications include measurement of pitch and roll in missiles, and angles of inclination where remote indication is desired. (*From new 20-page Catalog E-53, covering precision potentiometers and accelerometers, Edcliff Instruments, 383 N. Foothill Blvd., Pasadena 8, Calif.*)



SCHEMATIC

For this literature circle **510** on inquiry card.

Solar Cell

The Type S-1 Silicon Solar Cell is the first solar battery to be made commercially available. It is based on the research of the Bell Telephone Laboratories and manufactured by Western Electric Co., Inc.

The cell comprises a hermetically sealed large-area silicon p-n junction. The following characteristics are typical for exposure to illumination levels of direct noon sunlight:

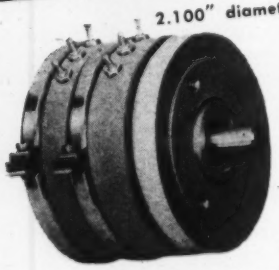
Internal impedance depends on light flux.

Under the above illumination level a typical cell will

DATA SHEET

FAIRCHILD PRECISION POTENTIOMETERS

2.100" diameter



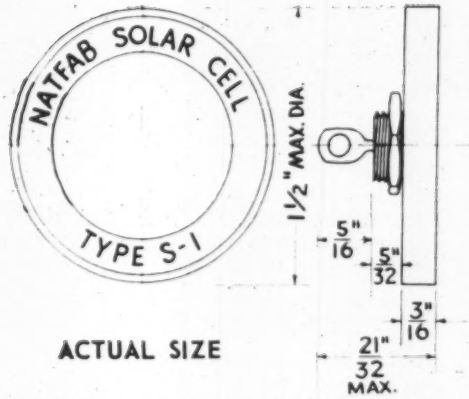
Type 747 — E Linear Potentiometer

Available with windings covering resistance range of 50 to 70,000 ohms; standard linearity tolerance of ± 0.15%. Clamp band provides unrestricted tapping area allowing up to 19 taps and simplifies phasing units in ganged assembly without disassembling units. Up to 6 units can be ganged on a single shaft. Cup width of .984 inches. Furnished with welded taps and end leads. Low starting torque only 1.0 oz-in per cup section. Low noise level and high resolution recommend units for computor assemblies, calibration controls, servo mechanisms, etc.

SAMPLES AVAILABLE ON ORDER

Fairchild's more complete line can help solve all your precision potentiometer problems. For more information write Fairchild Controls Corp., Potentiometer Division, 225 Park Avenue, Hicksville, L. I., N. Y., or 6111 E. Washington Blvd., Los Angeles, Cal., Dept. 140-688.

For more information circle **143** on inquiry card.



ACTUAL SIZE

measure 0.3 to 0.5 volt on open circuit; 0.25 volt across 10 ohms.

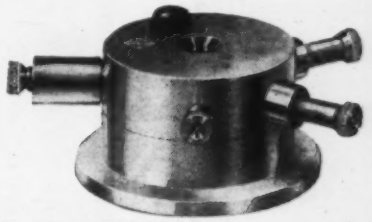
Will convert solar energy to electrical power at rate up to 10 mw. (*From new 2-page Technical Information Bulletin* 1-55, *National Fabricated Products, Inc., 2650 W. Belden Ave., Chicago* 47, *Ill.*)

For this literature circle **511** on inquiry card.

Micromanometer

Model MM-2 operates on a simple principle first proposed by Prandtl. Its basic function is to measure the unknown pressure difference between two points. Referring to the schematic diagram above, connect one point by tubing to tap 1 (the "static" tap) and the other point to tap 2. Then determine the zero reading of the instrument by turning valve 2 to "ZERO" (this places the "static" pressure at both points A and B) and adjusting micrometer-screw C until the meniscus coincides with the hairline viewed through the eyepiece. This micrometer reading is the zero value. Then, to measure, turn valve 2 to "ON" (this places

FOR MEASURING RADIOACTIVE EMISSION



8.3 x 6.5 x 3.5 cm. Weight 0.17 kg.

LINDEMANN-RYERSON ELECTROMETER

Was first used for photo-electric measurements. Is now used in conjunction with ionization chambers for the determination of radioactive emission. Compact, sturdy, high sensitivity, stable zero and requires no leveling. Capacitance is about 3 cm. Includes improvements developed by the Ryerson Laboratory.

OTHER CAMBRIDGE INSTRUMENTS

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"CHANG AND ENG" FAST NEUTRON DETECTOR
follows closely original design of U. S. Atomic Energy Commission. Consists of twin ionization chambers, Lindemann Electrometer, reading microscope and dry cells. Self-contained.

PRECISION IONIZATION METER (Failla Design)
A complete instrument for null methods of radioactivity measurement where background radiation effects must be eliminated.

Send for complete information

CAMBRIDGE INSTRUMENT CO., INC.
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PIONEER MANUFACTURERS OF PRECISION INSTRUMENTS
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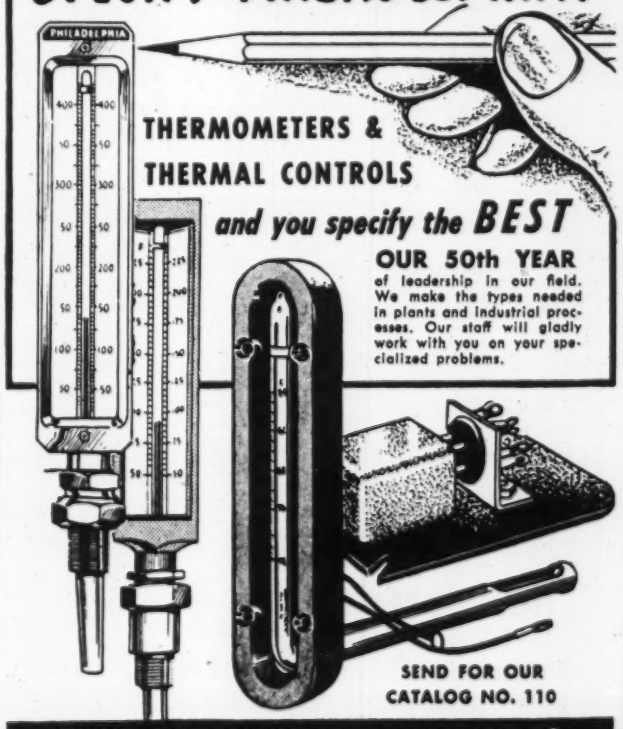

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of leadership in our field. We make the types needed in plants and industrial processes. Our staff will gladly work with you on your specialized problems.

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A New Concept in Optical Comparator Design...

new WILDER small parts Comparator model C

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- *Erect Image*
- *Eye Level Screen*
- *Horizontal Stage*

An Entirely New Model Optical Comparator Designed for 100% Production Inspection
ACCURATE - FAST - INEXPENSIVE
Promotes Inspection Economy

If you manufacture mass produced parts that are now being inspected or should be inspected on an Optical Comparator, the new Small Parts Comparator will enable you to inspect them quickly, accurately and economically at a surprisingly low per-piece inspection cost.

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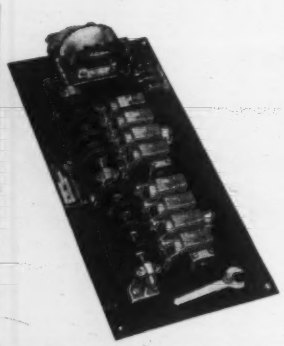
positive
snap-action
at 1 to 80 psi.

flexible
sequence control

dependable,
simple, sturdy



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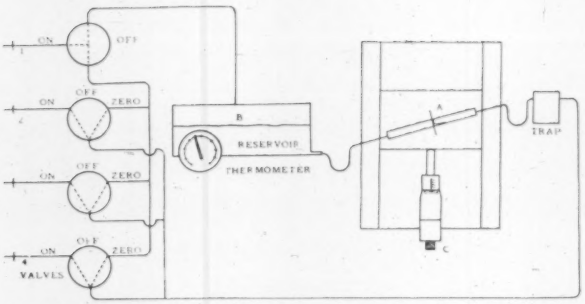
PNEUMATIC
TIMERS

Adjustment and change of sequence or cycle time is easy on ATC Pneumatic Cam Timers, custom-built from standard parts. Designed to operate at 3 to 15 psi. Minimum time setting is 1% of cycle; repeat accuracy, ¼%. Springless poppet—the only moving part of each valve—unaffected by over-pressuring to 100 psi, needs no lubrication. Stop-or repeat-cycle action.

Complete data in Bulletin N-101. Automatic Temperature Control Co., Inc., 5224 Pulaski Ave., Philadelphia 44, Pa.

Represented in Canada by: Powerlite Devices, Ltd., Toronto, Montreal and Vancouver

For more information circle **147** on inquiry card.



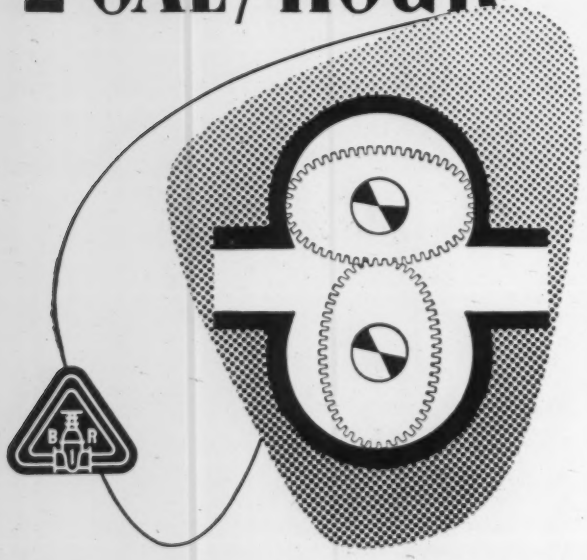
the unknown pressure difference betweeen points A and B) and adjust the micrometer screw until the meniscus again coincides with the hairline. This micrometer reading minus the zero value is the desired pressure difference in inches of manometer fluid. By switching valve 2 back to "ZERO", the zero value can be checked. Valve 1 permits observation of any of the pressures at taps 1, 2, 3, 4 independently against a closed reservoir. Features: Zero readings reproducible to better than 0.0002". Instrument is readable to 0.0001" in ordinary light. (*From new 2-page Bulletin* 17, *Flow Corp., 283 Concord Ave., Cambridge* 38, *Mass.*)

For this literature circle **512** on inquiry card.

Synchroprinter High-speed Printer

A synchroprinter consists of a motor which drives a print roll and synchronizing pulse generator. This stream of pulses is usually fed to a conventional electronic counter for character identification which, when it matches the desired character sign in the computer or other external registers, then triggers the printer-hammer thyraton firing circuit. This causes a magnetically operated hammer

HOW TO MEASURE
2 GAL/HOUR



WITH THE
OVAL WHEEL METER
(P.D. METER)
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MANNHEIM-WALDHOF · GERMANY

REPRESENTED IN USA
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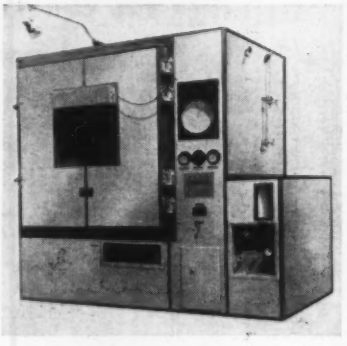
TEST CHAMBERS

To Meet
MIL-E-5272
And Others

- Top Opening
- Front Opening
- Walk-In



Write for Bulletin SS55

DEVELOPMENT ENGINEERING
COMPANY
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MFRS. OF ENVIRONMENTAL TEST EQUIPMENT
FUNGUS TESTING—COLD—HEAT—ALTITUDE—HUMIDITY

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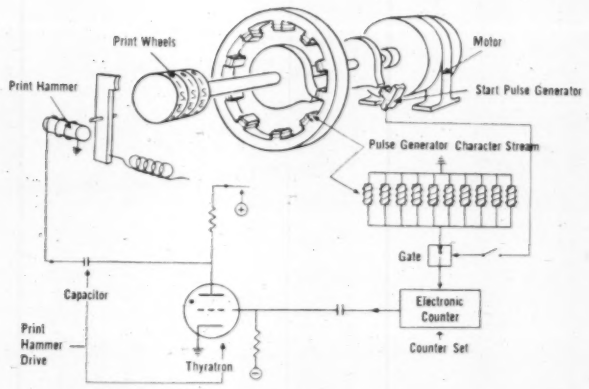


to imprint on the paper the character appearing at the printing position at that instant.

As an example in a standard digitalANelex synchro-printer, the print roll has 40 "wheels" of ten characters each engraved on its periphery. As the print roll rotates, a sync generator emits a pulse each time a character is in the "print" position, thus ten pulses are generated during every revolution of the print roll. Another sync pulse generator produces a single pulse per revolution which is used to determine the beginning of the printing cycle and may be used for timing auxiliary functions.

A separate pulse is used to advance the paper when all the printing desired on one line is completed.

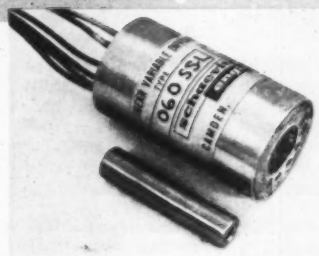
The print roll rotates continuously at a sufficiently high speed to permit printing an entire line of 40 characters *and* advancing the paper at a rate of approximately 15 lines—or 600 characters printed in *one second*, in this model. (*From new 8-page brochure DR-255-2.5 ANelex Corp., Concord, N. H.*)

For this literature circle **513** on inquiry card.

INSTALL

Schaevitz Shielded LVDT's

wherever magnetic fields create a problem



SCHAEVITZ type 060 SS-L magnetically-shielded linear variable differential transformers can be installed with metallic mounts and clamps and in closely-spaced metal parts assemblies without fear of changing electrical characteristics of the transformers. They are insensitive to stray magnetic fields from external sources and are highly sensitive instruments for producing a voltage which is very accurately proportional to linear displacement.

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- LINEAR RANGE: ± 0.060 inch (total linear travel 0.120 inch)
- LINEARITY: within 0.5% of nominal full-range output
- LVDT RESOLUTION: unlimited —effective limit determined by user's indication or control equipment
- SENSITIVITY: 0.5 megohm load: at 60 cps: 1.4 MV out 0.001 inch volt in— at 400 cps: 4.2 MV out 0.001 inch volt in
- PRIMARY EXCITATION: 6.3V, nominal input
- FREQUENCY: for any chosen value in 50-20,000 cps range
- OUTPUT AT NULL POSITION: less than 0.5% nominal full-range output
- PHASE ANGLE, approx.: at 60 cps, 0.5 megohm load: 70°— at 400 cps, 0.5 megohm load: 21° —at 400 cps, 600 ohms load: 0°
- AMBIENT TEMPERATURE RANGE: —65° to +200°F
- PRICE: $27.50

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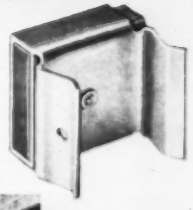

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For more information circle **152** on inquiry card.

New Literature . . .

INSTRUMENTS and AUTOMATION

For literature use the postage-free order card on page 1569.

AUTOMATION

Automation. New 16-page issue of "Kelloggram" (No. 3) describes automation (control by instruments) in petroleum and chemical industries.—M. W. Kellogg Co., 225 Broadway, N. Y. 7, N. Y.

Circle **514** on inquiry card.

Process Instrumentation. New 12-page Bulletin 90-241-10 describes and illustrates maker's instrumentation for water treatment plants. Includes operating table and flow diagram.—Fischer & Porter Co., Hatboro, Pa.

Circle **515** on inquiry card.

Machine Tool Control. New 4-page Booklet GEA-6328 describes maker's "Numerical Positioning Control" for automatic positioning and control of machine tools with standard business-machine punch-card data.—General Electric Co., Schenectady 5, N. Y.

Circle **516** on inquiry card.

Waste Treatment. New 16-page Booklet 90-242-10 describes & illustrates instrumentation for treating cyanide and hexavalent chromium wastes.—Fischer & Porter Co., Hatboro, Pa.

Circle **517** on inquiry card.

Textile Instrumentation. New 4-page leaflet describes textile-manufacturing instruments—for measuring and recording longitudinal and lateral weight variations of picker-lap automatically, tension analyzer, uniformity analyzer, imperfection counter, etc.—Brush Electronics Co., 3405 Perkins Ave., Cleveland 14, Ohio.

Circle **518** on inquiry card.

Photoelectric Controls. New 16-page illustrated Catalog 55 describes maker's photoelectric and electronic timing controls. Includes applications in level control, smoke control, production counting, etc.—Autotron Co., P. O. Box 722-Q, Danville, Ill.

Circle **519** on inquiry card.

Rotary Hopper. New 4-page leaflet describes maker's "160" automatic-feed rotary hopper. Feedmatic, Inc., 22519 Telegraph Rd., Detroit 19, Mich.

Circle **520** on inquiry card.

Water System Control. New 6-page Bulletin 285-M30 describes maker's flow and pressure control in water-filtration and waste-treatment plants.—Builders-Providence, Inc., 345 Harris Ave., Providence, R. I.

Circle **521** on inquiry card.

Sorting Unit. New 2-page descriptive Bulletin 551 illustrates maker's Autosort "Model 101" electronic gaging and sorting unit.—Cleveland Instrument Co., 735 Carnegie Ave., Cleveland 15, Ohio.

Circle **522** on inquiry card.

Process Control System. New set of bulletins (285-M41, 285-M10, 470-M4) describes maker's "Pneumaster" controller "Model ACH-1" for controlling and indicating flow, liquid level, pressure and temperature; also "Model FCP" filter operating console and filter control system.—Builders-Providence, Inc., Providence 1, R. I.

Circle **523** on inquiry card.

MONITORS

Scanning, Monitoring Equipment. New 4-page Bulletin A-7 pictures and describes maker's scanning and monitoring equipment for control of multipoint temperature and other processes.—Kybernetes Corp., Nine E. Fortieth St., New York 16, N. Y.

Circle **524** on inquiry card.

Alarm System. New 2-page Bulletin 7410 describes maker's "Multalarms" alarm system for sewage and process application. Bulletin 7200 describes 'Protectrols" which prevents deep-well or centrifugal pumps running without water.—Automatic Control Co., 995 University Ave., St. Paul 4, Minn.

Circle **525** on inquiry card.

Annunciator. New 4-page booklet describes maker's "Electro-Pane" window-type annunciator featuring annunciator chassis behind marked windows.—Electro-Devices, Inc., 4025 Easton Ave., St. Louis 13, Mo.

Circle **526** on inquiry card.

Annunciator. New 4-page folder describes maker's "Electro-Larm" unit-type annunciator featuring illuminated key switch.—Electro-Devices, Inc., 4025 Easton Ave., St. Louis 13, Mo.

Circle **527** on inquiry card.

VALVES

Control Valves. New 4-page Specification Sheet 429 describes maker's "Series 400" diaphragm control valves.—Minneapolis-Honeywell Regulator Co., Ind. Div., Wayne and Windrim Aves., Phila. 44, Pa.

Circle **528** on inquiry card.

Balanced Valve Regulators. New 36-page Bulletin 1094 describes and illustrates maker's high- and low-pressure balanced valve regulators. Includes applications in series for safety control, with relief valves, with pilot loading, as 2-stage reduction unit with safety pilot loading, etc.—Rockwell Mfg. Co., 400 N. Lexington Ave., Pittsburgh 8, Pa.

Circle **529** on inquiry card.

Valves. New set of Bulletins (210, 217, 240 & 260) pictures and describes maker's "Electroflow and Electro-Mesurflo" valves, "Straitflo" strainer; and "Shur-flo" interlock.—Hays Mfg. Corp., Erie, Pa.

Circle **530** on inquiry card.

Valves. New 4-page Bulletin 101-A presents detailed descriptive and dimensional information on maker's wing-cap packed valves. Bulletin 201-A presents information on shut-off, relief, and check valves, etc.—Henry Valve Co., 3215 North Ave., Melrose Park, Ill.

Circle **531** on inquiry card.

Air Release Valves. New 8-page Bulletin 1204 describes maker's "Type AGFD" automatic air release valve for water, sewage and industrial use.—Simplex Valve and Meter Co., 7 E. Orange St., Lancaster, Pa.

Circle **532** on inquiry card.

Sampling Valves. New 2-page Data Sheet 270 describes and illustrates maker's "No. 23" drain or sampling valve.—Jerguson Gage & Valve Co., 80 Fellsway, Somerville 45, Mass.

Circle **533** on inquiry card.

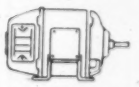
Restrictor Valves. New 2-page Data Sheet Series 1100 describes and illustrates maker's fixed one-way or two-way restrictor-type valves.—Aircraft Products Co., 300 Church Rd., Bridgeport, Pa.

Circle **534** on inquiry card.

Air Valves. New 8-page bulletin describes and illustrates maker's solenoid, hand, and pilot air valves; also dial feed tables and cylinder actuators.—A. K. Allen Co., 57 Meserole Ave., Brooklyn 22, N. Y.

Circle **535** on inquiry card.

MOTORS, SERVOS



Servomechanism Components. New 20-page booklet is manual of rotating servomechanism components, and adjustment and setting tools.—Norden-Ketay Corp., 555 Broadway, New York 12, N. Y.

Circle **536** on inquiry card.

Timing Motors. New 4-page descriptive bulletin presents specifications and applications of maker's synchronous timing motors.—United States Time Corp., Waterbury 20, Conn.

Circle **537** on inquiry card.

Motors. New 4-page Bulletin 1879 pictures and describes maker's "Types J & E" totally-enclosed and explosion-proof motors.—U. S. Electrical Motors, Inc., Box 2058, Los Angeles 54, Calif.

Circle **538** on inquiry card.

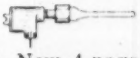
Motors. New 4-page brochure describes and illustrates maker's fractional-hp clutch-gear motors used for business machines, automatic displays, signal lights, etc.—Molon Motors and Coil Co., 3349 W. Addison St., Chicago 18, Ill.

Circle **539** on inquiry card.

Motors. New 4-page issue of "Bodine Motorgram" (Vol. 35, No. 4) presents characteristics and application of maker's shaded-pole motor used on fans, timing devices, heaters, agitators, etc.—Bodine Electric Co., 2282 W. Ohio St., Chicago 12, Ill.

Circle **540** on inquiry card.

TEMPERATURE



Radiation Pyrometers. New 4-page Brochure TDS-IRPS describes maker's "IR-1 & IR-2" infrared radiation pyrometers for measuring temperature variations without direct contact of process under control.—Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, L. I., N. Y.

Circle **541** on inquiry card.

High-sensitivity Thermocouples. New 2-page Specification Sheet 57 describes maker's two-wire thermocouples with outside diameters of only ⅛ inch and 3/16 inch (recommended in place of pencil-type tc).—Minneapolis-Honeywell Regulator Co., Ind. Div., Wayne and Windrim Aves., Phila. 44, Pa.

Circle **542** on inquiry card.

TC Protecting Tubes. New 4-page Bulletin 11-13 describes maker's "Serv-Rite" standard thermocouple protecting tubes and protecting wells.—Claud S. Gordon Co., 3000 S. Wallace St., Chicago 16, Ill.

Circle **543** on inquiry card.

Pyrometers, Meter Relays. New 2-page Bulletin MP-1 pictures and describes maker's ruggedized-sealed contact-meter-relays, panel indicators, and pyrometers.—Assembly Products, Inc., Chesterland, Ohio.

Circle **544** on inquiry card.

Indicating Pyrometers. New 2-page Bulletin F 6048-1 describes maker's "Models 141P, 192 and 196" indicating pyrometers for continuous temperature measurement and indication in industrial plants and laboratories.—Wheelco Instruments Div., Barber-Colman Co., Rockford, Ill.

Circle **545** on inquiry card.

Surface Radiation Pyrometer. New 14-page booklet and 4-page folder describe maker's new "Land" surface pyrometer, a radiation pyrometer for measuring temperature of non-conducting surfaces.—Fielden Instrument Div., Robertshaw-Fulton Controls Co., 2920 N. Fourth St., Phila. 33, Pa.

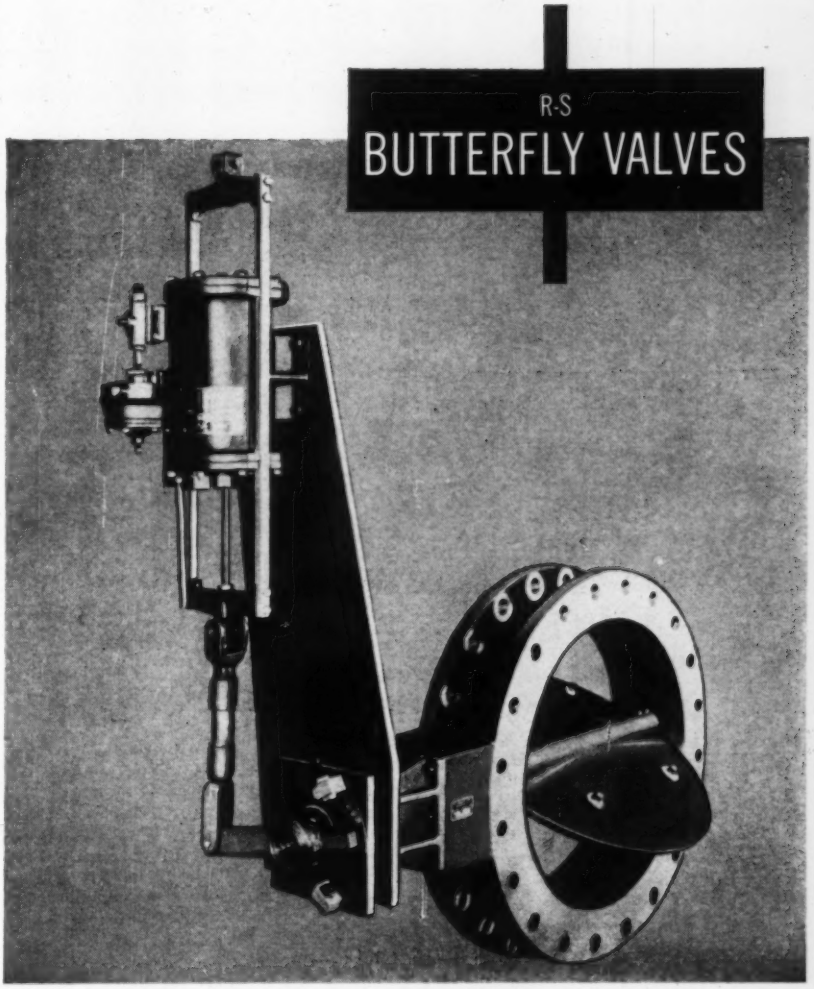
Circle **546** on inquiry card.

Temperature Instruments. New 24-page Catalog 12-A-10 describes maker's complete line of temperature instruments for indicating, recording, controlling, transmitting, compensating, and programming temperatures. Includes types of elements, principles, and complete instrumentation for industrial uses.—Fischer & Porter Co., Hatboro 35, Pa.

Circle **547** on inquiry card.

Thermocouples, Tables. New 28-page booklet pictures and describes maker's temperature and pressure-sensing devices for aviation and industrial instrumentation. Includes 8 pages of tc tables and temp-scale conversions.—Harco Laboratories, Inc., New Haven, Conn.

Circle **548** on inquiry card.



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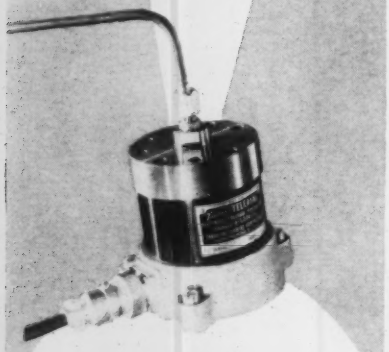

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NEW LITERATURE

Thermocouple Wire. New 4-page bulletin presents specifications on maker's thermocouple wire (copper, iron, constantan, chromel, and alumel) and insulations.—Harco Laboratories, Inc., New Haven, Conn.

Circle **549** on inquiry card.

Thermostatic Switches, Panel Indicators, Components. New 16-page issue of "This Month" (Summer 1955) pictures and describes distributor's line of actuators, attenuators, blowers, counters, motors, switches, etc.—Herbach & Rademan, Inc., 1204 Arch St., Philadelphia 7, Pa.

Circle **550** on inquiry card.

Thermostats. New 6-page leaflet describes maker's miniature hermetically-sealed thermostats used for thermal sensing, temperature control, etc. —Chatham Controls Corp., 110 Summit Ave., Chatham, N. J.

Circle **551** on inquiry card.

PRESSURE, WEIGHT

Digital Pressure Gages, Signal Generators. New 4-page folder "Precision Electronic Measurement and Control Instruments" describes maker's line of signal generators, VSWR indicators, incidental FM meters and "Vibrotron" digital-type pressure gages and accessories.—Byron Jackson Co., 492 E. Union St., Pasadena, Calif.

Circle **552** on inquiry card.

Pressure, Displacement Transducers. New 12-page set of 2-page and 4-page technical bulletins describes maker's pressure and displacement transducers "Series 214, 224 & 226" of potentiometer- and diaphragm-capsule types.—Colvin Labs., Inc., E. Orange, N. J.

Circle **553** on inquiry card.

Pressure, Position Transducers. New 2-page Bulletin 155-2-102B and 155-2-103B presents specifications on maker's "Model GP-8" high-range pressure transducer and "Model LP-1" linear position transducer.—North American Instruments, Inc., 2420 N. Lake Ave., Altadena, Calif.

Circle **554** on inquiry card.

Pressure Generators. High-pressure Generator-controller. New 4-page Bulletin 755 describes maker's "aiROY-metric" pressure generators for producing hydrostatic pressures of up to 500 times normal plant air pressure, and automatically controlling it while pumping high-pressure process fluids, etc.—Milton Roy Co., 1300 E. Mermaid Lane, Philadelphia 18, Pa.

Circle **555** on inquiry card.

Pickups for Pressure, Acceleration. New set of 24 2-page engineering data-sheet inserts (superseding pages of latest Wiancko Catalog) present specifications on maker's pressure pickups, d-p pickups, acceleration pickups, data systems, carrier oscillators, etc.—Wiancko Engineering Co., 255 N. Halstead Ave., Pasadena 8, Calif.

Circle **556** on inquiry card.

Pressure Controller. New 8-page Bulletin 542 describes maker's "Micro Delta p" back-pressure control system comprising Bellofram diaphragm and piston-type valve plug.—Industrial Engineering Corp., 525 E. Woodbine, Louisville 8, Ky.

Circle **557** on inquiry card.

Grain Scale. New 2-page Bulletin 5502 describes maker's "Models F, FF and JJ" automatic mill grain scale.—Richardson Scale Co., Clifton, N. J.

Circle **558** on inquiry card.

Pressure Control. New 2-page descriptive Bulletin CO-30 illustrates maker's "Series 80B" high- and low-limit-type pressure controls for steam, and non-corrosive liquids and gases.—Combustion Control Div., Electronics Corp. of America, 718 Beacon St., Boston 15, Mass.

Circle **559** on inquiry card.

TORQUE

Torquemeters. New 2-page Data Sheet 10.18-10 describes system comprising Baldwin SR-4 pick-up units and Brown ElectroniK instruments to measure torque of engines, pumps, etc.—Minneapolis-Honeywell Regulator Co., Ind. Div., Wayne & Windrim Ave., Phila. 44, Pa.

Circle **560** on inquiry card.

Torsion Tester. New 4-page Brochure TT-1/55 describes maker's "Model 935" torsion tester, and "Model 942" torsion spring tester for testing torsion springs.—John Chatillon & Sons, 85 Cliff St., New York 38, N. Y.

Circle **561** on inquiry card.

FLOW

Magnetic Flowmeter. New 2-page Data Sheet 831-32 describes maker's magnetic flowmeter for controlling rate of flow of filter effluent and other process fluids.—Foxboro Co., Foxboro, Mass.

Circle **562** on inquiry card.

Venturi Nozzle. New 4-page Bulletin 130-K3A describes maker's "Model NZIF" Venturi insert nozzle for metering liquid, steam, air, or gas. —Builders-Providence, Inc., 345 Harris St., Providence 1, R. I.

Circle **563** on inquiry card.

Flowmeters. New 20-page Bulletin 33 describes maker's "Niagara" positive-displacement meters for oils, gasoline, water, chemicals, etc.—Buffalo Meter Co., 2917 Main, Buffalo 14, N. Y.

Circle **564** on inquiry card.

Flowmeter Calibration Equipment. New 4-page brochure describes maker's "Type 350" flowmeter calibration and test stand; "Model 3" flowmeter tester to pinpoint trouble in fluid flow system; and field model "39A".—Bone Engineering Corp., 701 W. Broadway, Glendale 4, Calif.

Circle **565** on inquiry card.

High-accuracy Flow Calibrators. New 4-page issue of 'Ratonews" (Vol. 4, No. 5) describes maker's standpipe-system calibrators for measuring mass rates of flow from 50 to 600,000 pph.—Fischer & Porter Co., Hatboro, Pa.

Circle **566** on inquiry card.

Hydraulic Pumps Controls. New 56-page illustrated Catalog 5001A describes maker's line of oil hydraulic pumps, controls and accessories. Section on pressure control includes relief valves, sequence valves, pressure switches, etc.—Vickers, Inc., 1400 Oakman Blvd, Detroit 32, Mich.

Circle **567** on inquiry card.

Anemometer. New 2-page Bulletin 18 pictures and describes maker's hot-wire anemometer for rapid response measurements of air stream velocity. —Flow Corp., 283 Concord Ave., Cambridge 38, Mass.

Circle **568** on inquiry card.

Micro-Bellows Pump. New 2-page bulletin describes maker's "Model P" Corson-Cerveny micro-bellows pump. —Research Appliance Co., Pittsburgh 9, Pa.

Circle **569** on inquiry card.

LEVEL

Tank Level. New 4-page descriptive Bulletin 501 illustrates maker's "Model 8 Magnalux" magnet-follower tank gage for indicating liquid level. —Liquidvision Gauge & Control Corp., P. O. Box 51, Oceanside, L. I., N. Y.

Circle **570** on inquiry card.

ANALYTICAL

High-shear Viscometers. New 8-page Bulletin MSP-125 describes maker's new principle in design of high-shear viscometers (as for paper coating slurries).—Hagan Corp., Pittsburgh 30, Pa.

Circle **571** on inquiry card.

Viscometer. New 2-page "Newsletter" (Vol. 2, No. 11) describes maker's "One-Shot" viscometer comprising a disposable "orifice cup."—Gardner Lab., Inc., Bethesda 14, Md.

Circle **572** on inquiry card.

Infrared Analyzer. New 4-page Data Sheet ND46-91(1) presents information on the installation, operation and maintenance of maker's infrared-type analyzer for processes.—Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

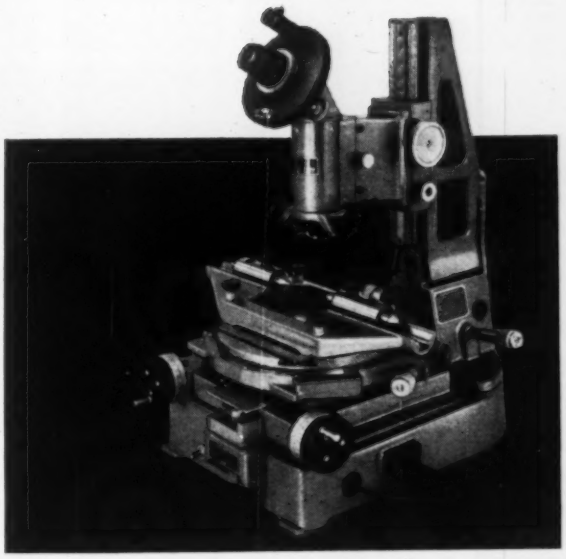
Circle **573** on inquiry card.

pH, Redox Electrodes. New 4-page reference table of Beckman electrodes lists and describes sixty electrodes for pH and oxidation-reduction, including ranges, body and lead lengths, catalog numbers, and prices.—Will Corp., Rochester 3, N. Y.

Circle **574** on inquiry card.

Vapor Fractometer. New 6-page leaflet describes maker's "Model 154 Vapor Fractometer" for analyzing gases and low-boiling liquids.—Perkin-Elmer Corp., Norwalk, Conn.

Circle **575** on inquiry card.



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Reading to	1 minute
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WRITE FOR BULLETIN NO. 147-50

For more information circle **155** on inquiry card.

Raman Spectrometer. New 4-page brochure presents new "Model R" photoelectric recording Raman spectrometer.—Perkin-Elmer Corp., Norwalk, Conn.

Circle **576** on inquiry card.

Quantrometric Steel Analysis. New 4-page issue of "Spectrographer's Newsletter" (Vol. 8, No. 2) features article on "Quantrometric Determinations of Carbon and Phosphorus in Steel."—Applied Research Labs., P. O. Box 1710, Glendale 5, Calif.

Circle **577** on inquiry card.

Flow Colorimeter. New 4-page descriptive Bulletin 383 illustrates maker's industrial flow colorimeter for automatically measuring, recording, controlling color, intensity and turbidity in gaseous and liquid process streams.—Beckman Div., Fullerton, Calif.

Circle **578** on inquiry card.

Oxygen Analyzer. New Bulletin 110-A describes maker's "Model 2B2B" dissolved-oxygen analyzer for steam-generating-plant operations.—Arnold O. Beckman, Inc., 1020 Mission St., South Pasadena, Calif.

Circle **579** on inquiry card.

Vapor Pressure Bombs. New 2-page Data Sheet 11526 describes maker's Reid vapor-pressure bombs for testing aviation and natural gasolines, bensol blends, and similar volatiles.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Circle **580** on inquiry card.

Indicating Titrator. New 4-page Bulletin 615 describes maker's "Precision-Shell" dual titrometer for potentiometric titrations on opaque solutions where color-indicator titrations are impractical.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Circle **581** on inquiry card.

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For more information circle 159 on inquiry card.

NEW LITERATURE

Solvent Recovery Still. New 2-page Data Sheet 11524 describes maker's solvent recovery still for recovery of carbon tetrachloride and other extraction vehicles.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Circle **532** on inquiry card.

LAB APPARATUS

Lab Apparatus. New 30-page Catalog 54 describes maker's glassworking equipment, burners, mercury cleaning apparatus, etc.—Bethlethem Apparatus Co., Inc., Front & Depot Sts., Hellertown, Pa.

Circle **583** on inquiry card.

Storage Tanks. New 2-page illustrated Bulletin 915 describes maker's line of distilled-water storage tanks.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Circle **584** on inquiry card.

Laboratory Equipment. New 6-page Bulletin (No. 2) presents list of maker's "special sale" lab items.—Scientific Glass Apparatus Co., Inc., Bloomfield, N. J.

Circle **585** on inquiry card.

Hypodermic Needle Cleaners. New 4-page Brochure C-108 pictures and describes maker's "Model S" hypodermic needle cleaner.—American Sterilizer Co., Erie, Pa.

Circle **586** on inquiry card.

Sink Trap. New 2-page data sheet describes maker's "Lanco" polyethylene sink trap for sinks where corrosive materials are handled.—Arthur S. LaPine Co., 6001 S. Knox Ave., Chicago 29, Ill.

Circle **587** on inquiry card.

RECORDING

Tape Recording. New 16-page Brochure 103 describes and illustrates nine basic "Building Block" components and accessories making up maker's magnetic-tape-recording systems.—A-V Mfg. Corp., 730 Fifth Ave., New York 19, N. Y.

Circle **588** on inquiry card.

Recording Charts. New set of "Technical Notes" comprises 16 specifications for "special" recording charts that can be used when designing recording instruments.—Technical Charts, Inc., Buffalo, N. Y.

Circle **589** on inquiry card.

Speedomax Recorder. New 2-page Data Sheet E-ND46(4) describes maker's "Speedomax Model S" adjustable-zero and adjustable-range recorder for recording force, temperature, voltage, speed, etc.—Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

Circle **590** on inquiry card.

Oscillographs. New 2-page descriptive bulletin illustrates maker's "MI-590, 580 & 581" oscillographs, and "MI 435" bridge balance unit.—Midwestern Instruments, P. O. Box 7186, Tulsa, Okla.

Circle **591** on inquiry card.

CEC Report. New 4-page midyear report to stockholders includes 4-page issue of "Consolidated Engineering Progress" (Vol. 1, No. 1), discusses CEC's '54 earnings, new CEC recording system, etc.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

Circle **592** on inquiry card.

Tape Phonograph. New 4-page issue of "Ampex Playback" (Vol. 1, No. 2) describes maker's "Model 612" tape phonograph for playing stereophonic and conventional tape recordings.—Ampex Corp., 934 Charter St., Redwood City, Calif.

Circle **593** on inquiry card.

Recording Techniques. New 4-page issue of "Alfax News" (Vol. 1, Edition 1) discusses maker's electrosensitive-paper recording techniques and reports on European Trade Fair in Hannover, Germany.—Alfax Paper and Engineering Co., Alden Research Center, Westboro 7, Mass.

Circle **594** on inquiry card.

Electronic Typer. New 4-page Brochure 190-655-1 pictures and describes maker's "Model 190" high-speed electronic typer for producing "hard copy" from output of electronic computer or magnetic tape.—Shepard Labs., 480 Morris Ave., Summit, N. J.

Circle **595** on inquiry card.

GAGING, TESTING

Continuous Thickness Gaging. New 4-page Data Sheet 10.9-la describes maker's beta-ray-type thickness and weight control system for rubber, foil, coatings and other moving sheet materials. Minneapolis-Honeywell Regulator Co., Ind. Div., Wayne and Windrim Aves., Phila. 44, Pa.

Circle **596** on inquiry card.

Runout Gages. New 2-page Bulletin 553 pictures and describes maker's recording runout gage which gives a permanent chart record of runout of motor commutators etc.—Cleveland Instrument Co., 735 Carnegie Ave., Cleveland 15, Ohio.

Circle **597** on inquiry card.

Gear Tester. New 4-page Bulletin 5503 describes maker's precision-gear tester for production checking of helical, spur and worm gears.—Arch Instrument Co., Inc., 101 Holmes St., N. Quincy, Mass.

Circle **598** on inquiry card.

Testing Machines. Three new 4-page Bulletins (QC-100-S, LT-500, QC-200) describe maker's "Model QC-200" 200-ton tester and "Models LT-500 and QC-100-S" compression and flexure testing machines.—Forney's, Inc., 209 Elm St., New Castle, Pa.

Circle **599** on inquiry card.

Creep Testing Machine. New 6-page bulletin describes and illustrates maker's "Model BJL-1" dynamic creep-testing machine.—Ivy Co., 15 Merwin St., Norwalk, Conn.

Circle **600** on inquiry card.

Surface Roughness. New 2-page Bulletin LT118 describes maker's "Type RE" rotary pilotor for production checking of microinch roughness around surfaces of rotation on small parts.—Micrometrical Mfg. Co., 345 S. Main St., Ann Arbor, Mich.

Circle **601** on inquiry card.

ULTRASONICS

Ultrasonic Gage. New 4-page Booklet V-101 describes maker's "Vidigage" ultrasonic resonance thickness gage for measuring thicknesses, detecting laminar discontinuities, etc.—Branson Instruments, Inc., 430 Fairfield Ave., Stamford, Conn.

Circle **602** on inquiry card.

Ultrasonic Generators. New 2-page bulletin describes maker's ultrasonic generators for research and small production in fields of bacteriology, chemistry, nutrition, etc.—Curtiss-Wright Corp., Caldwell, N. J.

Circle **603** on inquiry card.

Ultrasonic Machining. New 4-page booklet describes maker's ultrasonic machines for cutting, shaping, slicing, drilling and embossing unmachinable materials.—L. C. Miller Co., 5005 E. Slauson Ave., Los Angeles 22, Calif.

Circle **604** on inquiry card.

MAGNETICS

Electrical Laminations. New 40-page Bulletin L-355 describes and illustrates maker's electrical laminations for industrial application. Includes specifications on laminations and stacks.—Thomas & Skinner Steel Products Co., Inc., 1120 E. 23rd St., Indianapolis 7, Ind.

Circle **605** on inquiry card.

Magnets, Synchronous Drives. New 12-page issue of "Applied Magnetics" (Vol. 3, No. 4) features 8-page article on "Considerations in the Design of Synchronous Drives" (with driving and driven magnets).—Indiana Steel Products Co., Valparaiso, Ind.

Circle **606** on inquiry card.

Magnetic Laminations. New 4-page Technical Bulletin DMF-1 discusses "Magnetic Test Limits for Standard EI Laminations."—Thomas & Skinner Steel Products Co., Inc., 1120 E. 23rd St., Indianapolis, Ind.

Circle **607** on inquiry card.

Magnetic Cores. New 4-page leaflet presents specifications on maker's Ferramic "H" magnetic cores.—General Ceramics Corp., Keasbey, N. J.

Circle **608** on inquiry card.

OPTICAL

Optical Tooling. New 24-page illustrated Bulletin 808 describes maker's optical tooling (alignment telescopes, optical squares, collimating mirrors, etc.) for aircraft, power generators, shipbuilding, precision machines, etc. —Farrand Optical Co., Inc., Bronx Blvd. & East 238th St., New York 70, N. Y.

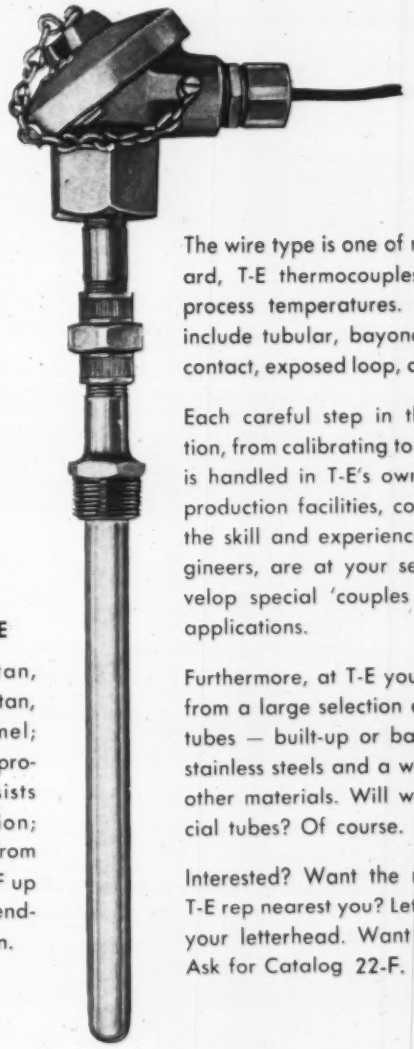
Circle **609** on inquiry card.

Photometric Equipment. New 6-page Bulletin 161 describes and illustrates maker's automatic photometric unit for automatic measuring of surface qualities (color, gloss, reflectance).—Gardner Laboratory, Inc., 4723 Elm St., Bethesda 14, Md.

Circle **610** on inquiry card.

DOES THERMO ELECTRIC MAKE WIRE TYPE THERMOCOUPLES?

CERTAINLY. TRY AND NAME A THERMOCOUPLE T-E DOESN'T MAKE.



WIRE TYPE, PROTECTED THERMOCOUPLE

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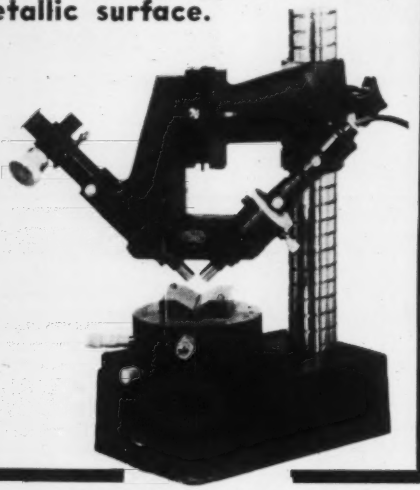

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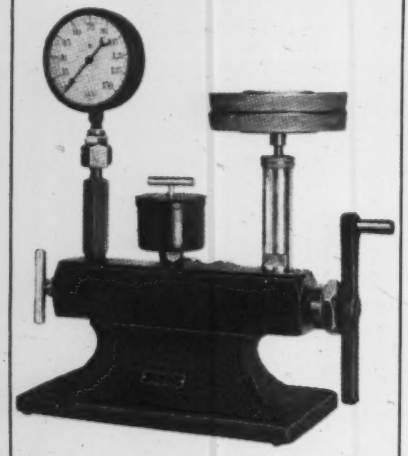
AMTHOR Dead Weight Pressure Gauge TESTER



Designed for simplicity and compactness, this tester incorporates the newest refinements and improvements and puts this rugged precision instrument in a grade above ordinary dead weight pressure gauge testers. Made in ranges up to 10,000 P.S.I., we guarantee accuracy of 1/10 of 1%. Supplied in metal carrying case and weight container as well as adapters and tools.

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NEW LITERATURE

Resolution Targets. New 4-page Bulletin 8000 describes maker's precision resolution targets used for determining resolving power of photographic lenses and other equipment.—W. & L. E. Gurley, Troy, N. Y.

Circle **611** on inquiry card.

Surveying Equipment. New 6-page folder describes and illustrates maker's scientific and surveying instruments, controllers and measuring instruments for industrial processing.—Askania-Werke, A.G., 4913 Cordell Ave., Bethesda, Md.

Circle **612** on inquiry card.

Glass Strain Tester. New 6-page Pamphlet PHYO 324E describes and illustrates maker's glass strain viewer for making visible thermic or outside pressure strain in transparent objects by means of polarized light.—Epic, Inc., 154 Nassau St., New York 38, N. Y.

Circle **613** on inquiry card.

TIME, COUNT

Electric Counters. New 4-page Bulletin ECS-44 describes and illustrates maker's heavy-duty "Super-Wizard" electric counters designed for 200 million count life.—Production Instrument Co., 710-20 W. Jackson Blvd., Chicago 6, Ill.

Circle **614** on inquiry card.

Industrial Counter. New 4-page issue of "Hewlett-Packard Journal" (Vol. 6, No. 11) describes maker's 120-kc industrial counter for measuring rpm, velocity, quantity, flow, etc.—Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.

Circle **615** on inquiry card.

Digital Clock. New 2-page Specification Sheet presents specifications and applications on maker's digital clock which digitizes time and also has binary-coded output.—Lawson Time Manufacturers, 1109 S. Fremont, Alhambra, Calif.

Circle **616** on inquiry card.

SPEED, FREQUENCY

Electronic Tachometer. New 4-page Catalog 19 describes maker's electronic tachometer for measuring rpm of rotating equipment.—Sunshine Scientific Instrument, 1810 Grant Ave., Phila. 15, Pa.

Circle **617** on inquiry card.

Tachometers. New 4-page folder describes and illustrates features of maker's industrial, stationary and centrifugal tachometers.—Boulin Instrument Corp., 65 Madison Ave., New York City, N. Y.

Circle **618** on inquiry card.

Speed-switches, Governors. New 8-page illustrated Bulletin 504S presents information on maker's line of speed-sensitive switches and overspeed governors.—Synchro-Start Products, 8151 N. Ridgeway Ave., Skokie, Ill.

Circle **619** on inquiry card.

Tachometer Tester. New 2-page bulletin describes maker's "Model T.T.,

Type M-5" portable tachometer tester used for rapid and accurate testing of aircraft electrical tachometer generators and indicators.—United Mfg. Co. Div., W. L. Maxson Corp., Hamden 14, Conn.

Circle **620** on inquiry card.

ACCELERATION

Accelerometer Calibration. New 4-page Bulletin 29 features article "A Basic Method of Determining the Dynamic Characteristics of Accelerometers by Rotation."—Statham Laboratories, Inc., 12401 W. Olympic Blvd., Los Angeles 64, Calif.

Circle **621** on inquiry card.

Impact Recording. New 4-page illustrated bulletin describes maker's "Impact-O-Graph" for recording magnitude and direction of impact.—Impact-O-Graph Corp., 1900 Euclid Ave., Cleveland 15, Ohio.

Circle **622** on inquiry card.

RADIOACTIVITY

Research Reactors. New 8-page Bulletin GEA-6326 pictures and describes maker's nuclear research reactors. Includes features and uses as a neutron beam generator, for production of radioisotopes, irradiation studies, nuclear engineering training, etc.—General Electric Apparatus Sales Div., Schenectady 5, N. Y.

Circle **623** on inquiry card.

Radioactivity Instruments. New 48-page Catalog P presents maker's radiation-measuring instruments, radiochemicals and accessories. Includes 6-page price list.—Nuclear Instrument and Chemical Corp., 223 W. Erie St., Chicago 10, Ill.

Circle **624** on inquiry card.

Radioactivity Instruments. New 16-page Catalog B illustrates and describes maker's nuclear equipment. Includes scintillation detectors, amplifiers, power supply, ratemeters, etc.—Technical Measurement Corp., 140-142 State St., New Haven 11, Conn.

Circle **625** on inquiry card.

Geiger Counters. New set of Bulletins (30MY505, 30MY501 and 30MY-504) describes maker's "Model 411" gun-type Geiger counter, walking-stick-type Geiger counter, and "Miracle Transistorized Audio" amplifier for Geiger counters, all featuring transistorized circuitry.—Universal Atomics Corp., 19 E. 48th St., New York 17, N. Y.

Circle **626** on inquiry card.

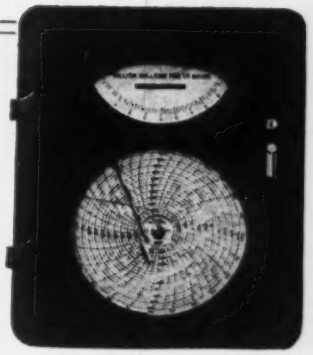
DATA PROCESSING, COMPUTING

Digital Converter. New 4-page Bulletin 360 presents applications and specifications of maker's ADC-1 digital converter featuring unambiguous output of 13 binary digits and high-speed clockwise or counter-clockwise operation.—Norden-Ketay Corp., Wiley St., Milford, Conn.

Circle **627** on inquiry card.

Data Processing, Strain Recording. New 16-page issue of "CEC Record-

FOR ACCURATE REMOTE MEASUREMENT of Flow, Liquid Level, Pressure



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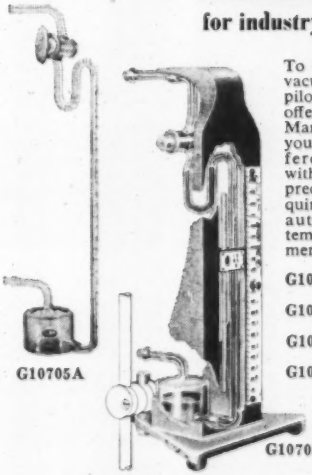

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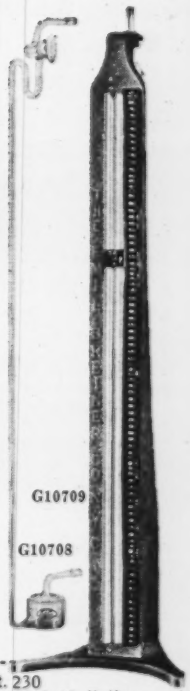

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NEW LITERATURE

ings" (Vol. 9, No. 3) concludes series on theory of strain gages and features articles on (1) use of maker's oscillograph to solve plane break up, (2) data processing in aircraft industry, (3) mass spectrometers for process, etc.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 15, Calif.

Circle **628** on inquiry card.

Analog Computer, Recorder. New 12-page booklet pictures and describes maker's six-channel recorder, analog computer, d-c analog computer, six-channel electronic function-generator, and AM-FM electronic multiplier.—Mid-Century Instrumatic Corp., 611 Broadway, New York 12, N. Y.

Circle **629** on inquiry card.

Analog Computer. New 20-page brochure illustrates services offered by the Princeton Computation Center, including typical problem operations from analysis to solution.—Electronic Associates, Inc., Computation Center, Box 582, Princeton, N. J.

Circle **630** on inquiry card.

Digital Computer. New 12-page pamphlet describes maker's general-purpose digital "Readix" computer.—J. B. Rea Co., 1723 Cloverfield Blvd., Santa Monica, Calif.

Circle **631** on inquiry card.

Automatic Computer Programming. New 4-page leaflet describes use of maker's electronic computer with automatic programming.—Remington Rand, Inc., 315 Fourth Ave., New York 10, N. Y.

Circle **632** on inquiry card.

Storage Drums. New 4-page Brochure PX-71843 describes maker's magnetic storage drums used as memory units for electronic computers and data reduction systems.—Remington Rand, Inc., 1902 W. Minnehaha Ave., St. Paul W4, Minn.

Circle **633** on inquiry card.

Analog Field Plotter. New 50-page Instruction Manual IM24 presents theory and use of maker's analog field plotter using potential-field patterns for studies in electrostatic, magnetostatic and electric current fields.—Sunshine Scientific Instrument, 1810 Grant Ave., Philadelphia 15, Pa.

Circle **634** on inquiry card.

ELECTRICAL, ELECTRONIC INSTRUMENTS

Potentiometers. New 2-page Data Sheet E-51(2) describes maker's "7655" portable potentiometers for emf measurements in plant and laboratory to accuracy of 1 mv.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

Circle **635** on inquiry card.

Electronic Kits. New condensed catalog describes features of maker's EICO kits for electronic test instruments, 46 models.—Electronic Instrument Co., Inc., 84 Withers St., Brooklyn 11, N. Y.

Circle **636** on inquiry card.

Circuit Recloser Tester. New 4-page bulletin describes maker's "Model 2040/ACTS" for testing, calibrating and coordinating circuit reclosers, sectionalizers and protective devices.—Multi-Amp Corp., 10 Third St., Newark 10, N. J.

Circle **637** on inquiry card.

Line Quality Tester. New 2-page Bulletin A-97 describes maker's line quality tester for testing overload of circuits before adding additional electrical line loads.—Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.

Circle **638** on inquiry card.

Continuity Analyzer. New 2-page Bulletin ESB 413-355 describes maker's "Model CA55" continuity analyzer for testing multiconductor cables or multiple resistive networks.—Technical Development Corp., Culver City, Calif.

Circle **639** on inquiry card.

Time Standards. New 4-page Bulletin G-2 discusses uses of WWV standard time and frequency broadcast standards, and presents maker's WWV and WWVR receivers.—Specific Products, 14515 Dickens St., Sherman Oaks, Calif.

Circle **640** on inquiry card.

Printed Circuitry. New 12-page Bulletin 3M-5740-655R describes advantages of printed circuitry for electrical and electronic systems. Includes discussion on printed circuits, plating techniques, design details, etc.—National Vulcanized Fibre Co., 1055 Beech St., Wilmington 99, Del.

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Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada

For more information circle **167** on inquiry card.

Panel Indicators. New 2-page illustrated Bulletin RUG131-4-55 describes maker's 1½" ruggedized panel indicators.—DeJur-Amsco Corp., 4501 Northern Blvd., Long Island City 1, N. Y.

Circle **642** on inquiry card.

Microwave Attenuation. New 8-page issue of "PRD Reports" (Vol. 4, No. 1) features article on microwave attenuation measurements.—Polytechnic Research & Development Co., Inc., 202 Tillary St., Brooklyn 1, N. Y.

Circle **643** on inquiry card.

Mixer-Amplifier. New 2-page Specification Sheet TP-101 describes maker's new transistorized mixer-amplifier for field use by broadcast and recording engineers.—Baird Associates, Inc., 33 Unversity Rd., Cambridge 38, Mass.

Circle **644** on inquiry card.

Colorscope. New 2-page Bulletin 50705 describes maker's "Model TE 6000 Colorscope" for evaluating color and monochrome television signals.—Tarc Electronics, Inc., 48 Urban Ave., Westbury, N. Y.

Circle **645** on inquiry card.

Oscillators. New 12-page issue of "Experimenter" (Vol. 29, No. 12) features article on "Unit R-C Oscillator —20 Cycles to 500 KC."—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Circle **646** on inquiry card.

Industrial Audio System. New 2-page Bulletin 1601-8 describes and illustrates maker's audio safety system for transmitting repeated safety reports, instructions, etc.—Mine Safety Appliances Co., 201 N. Braddock Ave., Pittsburgh 8, Pa.

Circle **647** on inquiry card.

POWER SUPPLIES

Power Generation, Distribution. New 28-page illustrated Booklet 873 describes GE's extensive line of electric equipment for the process industries. Includes types of generators, power distribution and conversion, and instrumentation.—General Electric, Schenectady 5, N. Y.

Circle **648** on inquiry card.

Transistor Batteries, Capacitors. New 6-page leaflet describes and illustrates maker's miniature batteries and capacitors for transistor circuits. Also contains electromagnetic spectrum chart reprint from "Tele-Tech."—P. R. Mallory & Co., Inc., P. O. Box 1558, Indianapolis 6, Ind.

Circle **649** on inquiry card.

Germanium Power Rectifiers. New 4-page Bulletin GPR-1 pictures and describes maker's germanium power rectifiers used for a-c to d-c power conversion.—International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.

Circle **650** on inquiry card.

Selenium Rectifiers. New 4-page issue of "International Rectifier News" (June-July, 1955) features articles on use of selenium rectifiers in Geiger counters, arc welding, etc.—International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.

Circle **651** on inquiry card.

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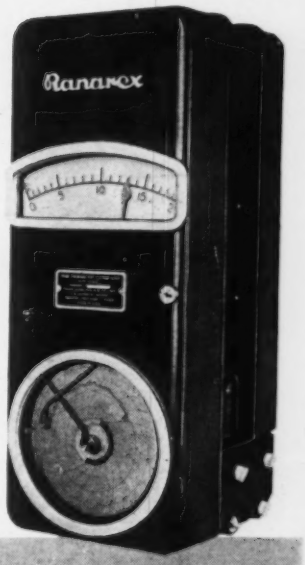

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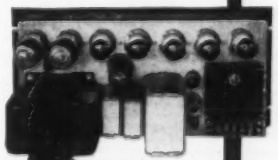

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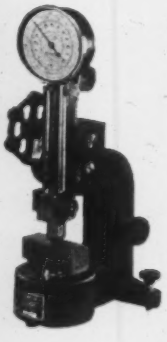

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bulletins describe and illustrate maker's "Type A" regulated d-c power supplies, germanium junction rectifier, 400-cps potentiometer power supply, and "Model MP-85" magnetic pulse generator.—Magnetic Research Corp., 200-202 Center St., El Segundo, Calif.

Circle **652** on inquiry card.

Power Supply. New 2-page Bulletin M60VMC describes maker's "Model M60VMC" magnetic amplifier tubeless regulated d-c power supply for 0 to 32 volts at 25 amp.—Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.

Circle **653** on inquiry card.

Power Supplies. New 4-page booklet describes maker's selenium and germanium rectifier power supplies.—Model Rectifier Corp., 557 Rogers Ave., Brooklyn 25, N. Y.

Circle **654** on inquiry card.

Bias Supply. New 2-page data sheet describes maker's "Series RB 20" regulated power supplies said to be "smallest bias supply ever developed."—Marine Electric Corp., 600 Fourth Ave., Brooklyn 15, N. Y.

Circle **655** on inquiry card.

Power Supply. New 16-page issue of "Experimenter" (Vol. 30, No. 2) presents specifications on maker's regulated power supply for unit instruments.—General Radio Co., 275 Massachusetts Avenue., Cambridge 39, Mass.

Circle **656** on inquiry card.

Power Supplies. New 2-page Bulletin 178 describes maker's line of d-c power supplies.—Opad Electric Co., 69 Murray St., New York 7, N. Y.

Circle **657** on inquiry card.

Battery Eliminator. New 2-page Bulletin 111 describes and illustrates maker's "Model G101F" aircraft battery eliminator used for ground operation and bench testing of airborne equipment.—Gates Electronic Corp., 2090 Barnes Ave., Bronx 62, N. Y.

Circle **658** on inquiry card.

Power Supply. New 2-page Bulletin 2432-100X describes maker's tubeless 100-ampere power supply.—Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.

Circle **659** on inquiry card.

SWITCHES, RELAYS

Pneumatic Switches. New 2-page illustrated Bulletin 357 describes maker's pneumatic switches for remote control of valves, etc.—Powers Regulator Co., Skokie, Ill.

Circle **660** on inquiry card.

Relays, Switches. New 4-page Catalog 1843 describes maker's complete line of stepping switches, relays and key switches for industrial use.—Automatic Electric Sales Corp., 1033 W. Van Buren St., Chicago 7, Ill.

Circle **661** on inquiry card.

Polar Relays. New 2-page Bulletin RH-7 pictures and describes maker's "Series PTW Type 203" polar relay used in composite signaling equipment and other polarized-relay applications.—Automatic Electric Sales Corp., 1033 W. Van Buren St., Chicago 7, Ill.

Circle **662** on inquiry card.

Relays, Switches. New 2-page Bulletin RH8 describes maker's electric relays and stepping switches used in circuit analyzer for testing electrical systems.—Automatic Electric Sales Corp., 1033 W. Van Buren St., Chicago 7, Ill.

Circle **663** on inquiry card.

Time Delay Relay. New 2-page illustrated bulletin describes maker's "Model NEH" Agastat time delay relay featuring instant-action double-throw auxiliary switch plus time delayed contacts.—A'G'A Div., Elastic Stop Nut Corp. of America, Elizabeth, N. J.

Circle **664** on inquiry card.

Switches. New 2-page Data Sheet P98 pictures maker's illuminated push button switches "31PB1" used in electronic, aircraft, mobile, marine, railway, etc.—Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle **665** on inquiry card.

Sealed Switches. New 2-page Data Sheet P103 presents maker's environment-proof switches.—Micro Switch Div., Minneapolis-Honeywell Regulator Corp., Freeport, Ill.

Circle **666** on inquiry card.

Counter Switch. New 2-page Data Sheet 101 presents maker's heavy-duty low-force counter switch used on counting applications.—Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle **667** on inquiry card.

Limit Switch. New 2-page Data Sheet 104 describes maker's 2-circuit limit switch used for controlling independent circuits. Data Sheet 105 describes double-pole double-throw environment-free switch.—Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle **668** on inquiry card.

Solenoid Actuators. New 2-page Bulletin 55-111 presents maker's "Type L22A" d-c electromagnetic actuators for reciprocating motion, vibration generators, remote switches, etc.—James Cunningham Son & Co., Inc., 33 Litchfield St., Rochester 8, N. Y.

Circle **669** on inquiry card.

Precision Switches. New 24-page Catalog 655 describes maker's precision, miniature, and snap-acting switches.—Unimax Div., W. L. Maxson Corp., 460 W. 34th St., New York 1, N. Y.

Circle **670** on inquiry card.

Rotary Solenoids. New 2-page Bulletin 9, "Ledex Engineering Sketchbook," has article on use of rotary solenoids for multichannel circuit selection.—G. H. Leland, Inc., Dayton 2, Ohio.

Circle **671** on inquiry card.

Relays. New 12-page illustrated Catalog 55 presents maker's large line of relays, including telephone-type, a-c and d-c, subminiature, plug-in, time delay, etc.—Magnecraft Electric Co., 3350 W. Grand Ave., Chicago 51, Ill.

Circle **672** on inquiry card.

Centrifugal Switches. New 2-page Bulletin 244 describes maker's "Syncro-Snap" centrifugal switches.—Torq

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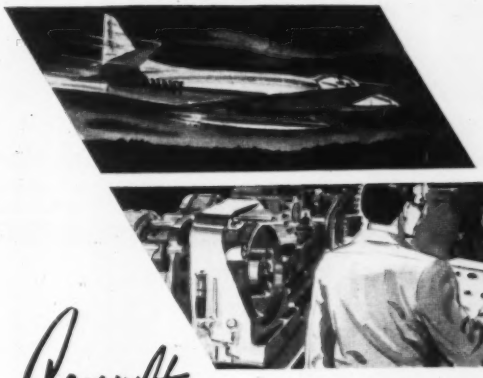

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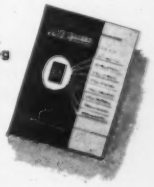

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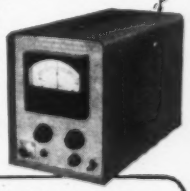

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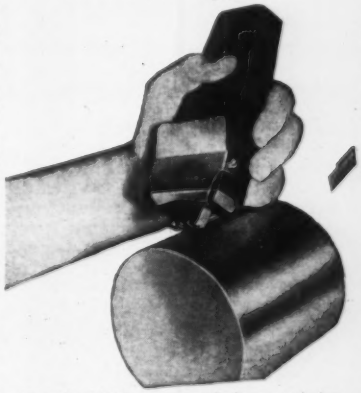

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NEW LITERATURE

Engineered Products, Inc., Bedford, Ohio.

Circle **673** on inquiry card.

Control Switches. New 4-page descriptive Bulletin 101 illustrates maker's aircraft control switches.—Aircraft Controls Div., Gorn Electric Co., Stamford, Conn.

Circle **674** on inquiry card.

Time Switches. New 2-page data sheet describes maker's "Series T670 Inter-Matic" time switches.—International Register Co., 2624 W. Washington Blvd., Chicago 12, Ill.

Circle **675** on inquiry card.

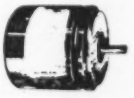
Timing Pushbutton. New 2-page Bulletin T-7 describes maker's timing pushbutton for manually starting and automatically terminating industrial processes.—Seeley Instrument Co., Inc., Niagara Falls, N. Y.

Circle **676** on inquiry card.

Relays. New 2-page Bulletin LM 4-55 describes maker's subminiature relay featuring ½-watt pull-in, 2-amp contacts.—Luther Mfg. Co., 7312 Varna Ave., No. Hollywood, Calif.

Circle **677** on inquiry card.

RESISTORS, POTENTIOMETERS



Multi-resistor. New 2-page bulletin describes maker's "BMR-105 Binary Multi-resistor" for digital-analog conversion, general computer use, etc.—Julie Research Labs., 341 E. 149 St., Bronx 51, N. Y.

Circle **678** on inquiry card.

Film Resistor. New 6-page issue of "PRD Reports" (Vol. 4, No. 2) features article on "A New Metal Film Resistor—The Polyohm."—Polytechnic Research & Development Co., Inc., 202 Tillary St., Brooklyn 1, N. Y.

Circle **679** on inquiry card.

Potentiometers. New 4-page leaflet describes maker's precision potentiometers for aircraft instrumentation.—Helco Products Corp., 2041 Colorado Ave., Santa Monica, Calif.

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Potentiometers. New 2-page Bulletin C078 describes maker's "Series C-078" ⅞-in subminiature precision potentiometers for aircraft, portable equipment, etc.—DeJur-Amsco Corp.,

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Circle **681** on inquiry card.

Potentiometer. New 2-page Bulletin C150-455 describes and illustrates maker's "Series C-158" precision ganging potentiometer.—DeJur Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle **682** on inquiry card.

ELECTRONIC COMPONENTS

Delay Lines. New 16-page brochure presents specifications on maker's lumped-constant delay lines.—ESC Corp., 534 Bergen Blvd., Palisades Park, N. J.

Circle **683** on inquiry card.

Power Tubes. New 24-page Booklet PG101B contains data on 178 vacuum power tubes, rectifier and vacuum-gage tubes, thyratrons, ignitrons and magnetrons. Price 20c.—Radio Corporation of America, Harrison, N. J.

Circle **684** on inquiry card.

Storage Tubes, Cells. Two new 2-page bulletins describe and illustrate maker's "6571" computer storage tube used in binary-digital computer systems and "6694" photoconductive cadmium-sulfide cell.—Radio Corp. of America, Harrison, N. J.

Circle **685** on inquiry card.

Quartz Crystals. New 8-page descriptive brochure illustrates maker's quartz crystals for frequency control. —Keystone Electronics Co., 114 Manhattan St., Stamford, Conn.

Circle **686** on inquiry card.

High-temp Conductors. New Bulletin 6A describes maker's high-temperature swaged-magnesia-insulated conductors.—Aero Research Instrument Co., 1040 Grand Ave., Chicago 22, Ill.

Circle **687** on inquiry card.

Capacitors. New 2-page data sheet describes maker's high-voltage high-current vacuum capacitors for medium and high power oscillatory systems.—Dolinko & Wilkens, Inc., 1901-7 Summit Ave., Union City, N. J.

Circle **688** on inquiry card.

Connectors. New 8-page illustrated brochure presents specifications on maker's miniature precision connectors.—Gorn Electronics Div., Gorn Electric Co., Inc., Stamford, Conn.

Circle **689** on inquiry card.

Hermetic Connectors. New 2-page Bulletin PH-1 describes maker's hermetic connectors which withstand mechanical shock of 100 g's, thermal shock from −300 to +500 F., etc.—Deutsch Co., 7000 Avalon Blvd., Los Angeles, Calif.

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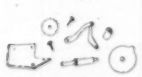
MECHANICAL COMPONENTS



Slip Coupling. New 10-page data sheet describes uses and properties of maker's slip coupling for controlling and fixing maximum torque transmitted from driver to driven machine. —Techniflex Corp., Port Jervis, N. Y.

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Clutch. New 8-page data sheet describes maker's 10-inch-pound-torque clutch featuring single revolution, non-reversing, overunning, indexing, etc.—Precision Specialties, 1342 E. 58th St., Kansas City 10, Mo.

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Spring Design. New 8-page data sheet describes various types of springs and spring-design criteria.—Spring Div., Hunter Spring Co., Lansdale, Pa.

Circle **693** on inquiry card.

Fiber Filter Discs. New 4-page bulletin pictures and describes maker's glass-fiber filter discs. Includes fiber diameters, disc densities available, etc.—Friedrich and Dimmock, Inc., Millville, N. J.

Circle **694** on inquiry card.

Vibration Mounts. New 8-page pamphlet presents maker's vibration and shock mounts.—Federal Shock Mount Corp., 1077 Intervale Ave., New York 59, N. Y.

Circle **695** on inquiry card.

Answers to I.Q. Quiz on page 1541

1.—c	5.—b	9.—c
2.—d	6.—d	10.—d
3.—c	7.—b	11.—b
4.—a	8.—c	

TUBING

Tube Fittings. New 12-page Catalog 4324 describes maker's "Intru-lok" tube fittings for instrumentation lines. —Tube & Hose Fittings Div., Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

Circle **696** on inquiry card.

Shaped Tubing. New 6-page Data Memorandum 17 describes maker's shaped tubing used for Bourdon springs, surgical instruments, batons, etc.—Superior Tube Co., 1566 Germantown Ave., Norristown, Pa.

Circle **697** on inquiry card.

Teflon Pipe. New 4-page Bulletin FTL-1 describes maker's line of laminated fluorocarbon resin pipe.—Resistoflex Corp., Belleville 9, N. J.

Circle **698** on inquiry card.

DRYERS

Instrument-quality Air. New 4-page Bulletin M-7155 describes maker's "M-Series Condensifilters" for removing contaminants from compressed air systems.—Hankison Corp., 951 Banksville Rd., Pittsburgh 16, Pa.

Circle **699** on inquiry card.

Midget Dryer. New 2-page Technical Bulletin 6551 pictures and describes maker's dessicant-type midget dryer for drying small flows of compressed gases to sub-zero dewpoints. —Industrol Corp., 472 Westfield Ave., E., Roselle Park, N. J.

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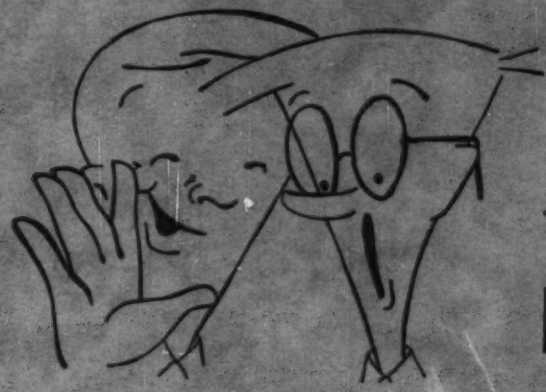

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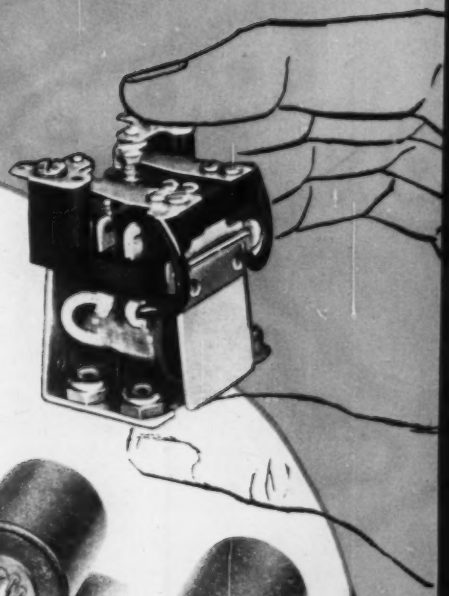

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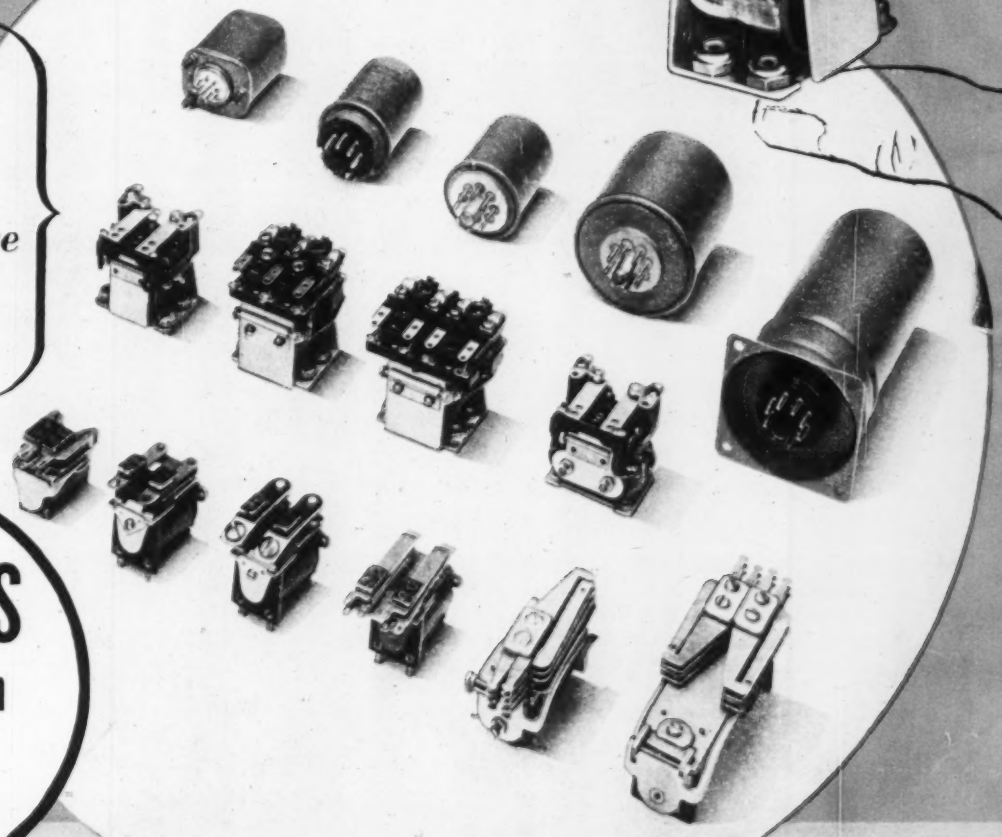

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